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# ERRATA.

P. 131, "Green Sandpiper, *Totanus ochropus*, Rare," should be omitted.

Page 169, 22nd line, read Mosasauridæ Gervais, 1853.

Page 187, insert after "Length 5 mm." the following paragraph: Two specimens, Magdalena Mts., Socorro Co., N. M. (F. H. Snow, Aug.).

Page 187, 8th line, read styliform instead of *stilliform*.

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Vol. III. JULY, 1894. No. 1.

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JOURNAL PUBLISHING HOUSE
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# Kansas University Quarterly.

Vol. III. JULY, 1894. No. 1.


# On Various Vertebrate Remains from the Lowermost Cretaceous of Kansas.


BY S. W. WILLISTON.


(With Plate I.)

Some months ago, Mr. C. N. Gould, principal of the public schools in Ashland, Clark Co., Kansas, sent to the University a number of vertebrate remains which he had found in the dark blue shale of the so-called Neocomian or Comanche Cretaceous, which outcrops in the vicinity of Ashland. Very recently I have had the opportunity of spending a few days in the investigation of the outcrops in company with Mr. Gould who materially assisted me. My thanks are due him, not only for the kindness which he showed me, but also for his placing all the specimens which he had collected at my disposal. The outcrop has been sufficiently well described by Prof. Cragin, who has the merit of first thoroughly studying and describing them. For further information concerning them, the reader is referred to his papers in the American Geologist. Suffice it to say here that in the region which we examined—upper Bluff Creek and Sand Creek with its tributaries—I found the beds in which the vertebrates occur, Cragin's No. 4, lying unconformably upon the red rocks of the Trias and surmounted by a thin stratum of the characteristic Dakota sandstone, and the thicker Tertiary sandstones of the uplands. The material is a dark blue shale, so strongly impregnated with iron that the fossils are always more or less injured after exposure. On moderately inclined slopes the bones, where found at all, were always disintegrated and incrusted with sulphate of lime. For this reason, they can be successfully sought only on steep slopes, and such are infrequent. Furthermore, the bones have always been found isolated, never together, so that it is hardly to be expected that even a tolerably complete knowledge of the fauna will be obtained in many years. The bones are found throughout the whole thickness of the shale, for fifty or seventy-five feet.

The remains, meagre as they are, are of great interest, because they represent the oldest marine Cretaceous fauna of America thus far discovered.

### FISHES.

A single vertebra of a form similar to that of the vertebræ of *Portheus* and which may be provisionally referred to that genus, has the following measurements.

| | |
|---|---|
| Diameter | 42 mm. |
| Length | 25 " |
| Depth of cup | 10 " |

The sides have been so affected by the action of lime sulphate that I can not make out any markings. They are only slightly concave.

Another vertebra, belonging to an entirely distinct type, resembles equally the vertebræ of a genus from the Kansas Niobrara. There is, however, in the middle an opening, as though for a persistent notochord. Its measurements are as follows:

| | |
|---|---|
| Diameter | 25 mm. |
| Length | 10 " |
| Diameter of opening | 8 " |

The centrum, as is seen, is very flat, and the cup shallow. The sides are markedly constricted, and have numerous, prominent, longitudinal ridges.

A single tooth agrees closely, both in form and size with *Lamna occidentalis* Leidy.

### TURTLE.

Turtles are represented by a single bone, the scapula-precoracoid of a species as large as *Protostega*. It differs very materially from the scapula of any turtle known to me in the great length of the humeral extremity. The other extremities are rather slender, and meet in a very obtuse angle.

### PLESIOSAURS.

Of the plesiosauroid remains there are eight or ten vertebræ, and various other bones, many of which are in poor preservation. They all appear to belong to one type, which I cannot distinguish from *Cimoliosaurus* in its narrowest sense. It is of course not certain that they all belong to this genus, and it is not improbable that there are distinct species represented by them. A single well-preserved, cervical vertebra will admit of specific description, as follows:

**Cimoliosaurus, n. sp.** (Pl I, figs. 1 and 2).

Centrum of cervical vertebra broader than high, with a single-headed rib or parapophysis, firmly united, springing from near the

middle below. Inferior surface gently carinate, and with small venous foramina. Sides rather deeply concave. Anterior zygapophyses approximated, concave, facing each other, and united below, forming a sort of "spout." Articular surfaces transverse, elliptical in outline, rather deeply concave, with a rounded eminence in the middle of the concavity, the rim above gently emarginated for the neural canal. The neural arch shows no trace of suture. Its measurements are as follows:

| | | |
|---|---|---|
| Length of centrum | 62 | mm. |
| Width of parapophysis at base | 30 | " |
| Transverse diameter of articulating surface | 83 | " |
| Vertical diameter of same | 55 | " |
| Width of neural canal | 20 | " |
| Height of lower margin of anterior zygapophyses above floor of neural canal | 25 | " |
| Distance between anterior zygapophyses | 20 | " |

Another, fairly well preserved caudal vertebra seems to belong to the same species. It has the articular faces deeply cupped in the middle, but with a broad, convex rim. On the under, longitudinally concave surface, there are three, feebly-marked ridges, with two venous foramina between them. The neural arches are united by sutures, and are slightly misplaced. The anterior zygapophyses are remote from each other and are inclined inwards at an angle of about 45 degrees. The following are its measurements:

| | | |
|---|---|---|
| Length of centrum below | 35 | mm. |
| Length between rims, same place | 25 | " |
| Transverse diameter of articulating surfaces | 47 | " |
| Vertical diameter of same | 45 | " |
| Depth of cups | 10 | " |

Another, larger, caudal vertebra, less well preserved, presents the same characters as the foregoing, but has the transverse diameter of the articulating surfaces (75 mm.) proportionally a little greater than the vertical (65 mm.).

A phalangeal bone has its articulating surfaces quite flat, measuring 40 mm. in the transverse, 30 in the vertical diameter. The bone has the shape of a flattened cylinder, with a gentle constriction, and measures 40 mm. in length.

A humerus, the shape of which is sufficiently well shown in the figure, has its lateral distal margins quite thin, and shows no facets for the fore-arm bones. It has a total length of about 110 mm. with a thickness in the middle of the distal end of 20 mm. and of the shaft above, 35 mm.

## CROCODILIA.

A single vertebra (fig. 5), wanting the neural arch, but otherwise well preserved, I refer somewhat doubtfully to *Hyposaurus* or a closely

allied form. It has the articular surfaces nearly flat, with the rims sharp, the body is gently concave on the sides and below, from in front back, and with striæ near each rim for about half an inch. The surface elsewhere is smooth and even, without venous foramina. A transverse section through the middle would give the greater part of an elliptical figure, with the lower side somewhat flattened. Only the base of the pedicels is present, and there is no indication of a sutural union. Springing from them, or possibly from the body itself produced above to meet the arch, there is on each side a stout transverse process, the base only of which is present, but which appears to be short. In shape and appearance, the centrum agrees well with one of *Hyposaurus rodgersi* from New Jersey, except in its more cylindrical shape. Its measurements are as follows:

| | |
|---|---|
| Length of centrum | 40 mm. |
| Transverse diameter of articulating face | 50 " |
| Vertical diameter of same face | 38 " |

The upper end of a femur (fig. 4), found in the vicinity of the plesiosaur paddle-bone which is figured, and which came from near the red beds, appears to belong to the same kind of an animal as does the vertebra described above. The shape is not unlike that of a human femur, with the trochanters evidently small, and placed much below the level of the head. The neck is stout, the head gently convex, with an angular border. The shaft below the trochanters is somewhat flattened from before back, but becomes more transverse below. The shaft is hollow, with firm walls not more than one-third of an inch in thickness. The portion preserved measures 210 mm., and I suspect that the bone when entire was about 275 mm. long. The diameter of the head is 50 mm., of the neck 40 mm., of the shaft at the upper part 50 mm. and at the lower part 38 mm.

LAWRENCE, May 1, '94.

POSTSCRIPT.—Since sending the above to the printer, I have received a paper without plates published by Prof. F. W. Cragin, May 12, in which are described and named a number of vertebrate remains from the same beds. They all appear to be different from those mentioned above, save possibly the *Lamna*.

May 19.

# A New Turtle from the Benton Cretaceous.

BY S. W. WILLISTON.

(With Plates II-V.)

Last November Mr. M. A. Low, General Attorney for the Chicago, Rock Island & Pacific Railroad, sent me for examination an unusually well preserved skull of a large turtle that had been obtained by Mr. Schrantz, Roadmaster of the Rock Island R. R., near Fairbury, Nebraska. From the matrix yet adhering to the specimen, I recognized its age as that of the Benton Cretaceous. Mr. Low, with his usual generous liberality towards the University, enabled me shortly after to visit the locality whence it was obtained. I found, as I had suspected, the formation in which it had been discovered to be Benton, and not far from its base. The late Dr. M. L. Eaton, of Fairbury, kindly assisted me in the examination of the region, and by his intervention I obtained various other portions of the skeleton. Unfortunately the specimen since it was excavated the preceding winter had suffered somewhat and as is usually the case many fragments had been lost. The portions that were obtained, however, are of the greatest importance, as without them the systematic position of the animal must have remained for a long time doubtful. As it is, most of the essential characters of the skeleton have been made out with certainty. It represents not only a new species, which I am glad to name in honor of Mr. Low as a slight appreciation of the many favors he has done the University and indirectly to science, but a new genus which I will call *Desmatochelys*, and a new family, *Desmatochelyidæ*.

I desire to express my best thanks not only to Mr. Low but to Mr. Schrantz and to Prof. Geo. Baur, of Chicago, of whose wide information on this order of reptiles he has kindly given me the benefit. His numerous contributions to the knowlege of the Testudinata justly entitle him to the honor of being the highest authority on these reptiles. To Dr. Eaton, but for whose enthusiastic interest in the local geology and science the specimen might never have been exhumed in anything like its present completeness, science is a debtor. A young man deeply and intelligently interested in natural science, beloved by all about him, kindly and obliging as he proved himself to me in my short acquaintance with him, his untimely death is to be greatly deplored.

## SKULL.

The skull was originally complete and in wonderful preservation having suffered but little from compression. Unfortunately the posterior inferior portion has been so injured that its characters are mostly obliterated.

**Parietals.** The parietals are elongate, narrow, gently arched bones, separated from each other by a distinct suture, and extending back over the supraoccipital for a considerable distance. Taken together the two bones, exclusive of the supraoccipital projection, form an elongated parallelogram, with a rounded boss or eminence in the middle in front. They send down a rather narrow fore and aft plate to join the pterygoids.

**Frontals.** The frontal bones are irregular in shape, though their entire form cannot be made out with certainty, owing to the obliteration of a part of the suture between them and the prefrontals. Posteriorly they unite by a nearly transverse, somewhat concave suture with the parietals, and, by an oblique suture running to near the middle of the superior orbital margin, with the postfrontals. The free orbital border is short and gently emarginate. In front, the transverse suture separating them from the prefrontals is very distinct on the outer two-thirds, but obliterated on the inner part. A very careful examination here shows, apparently with certainty, that the suture is not continued inwardly on the same line, but seems to turn forward and a little outward to join the nasal suture, as is indicated in the drawing, thus excluding the prefrontals from meeting in the middle line.

**Prefrontals.** With this interpretation, the prefrontals are small, and have an irregularly four-sided shape. Their orbital margin is even shorter than that of the frontals. The nasal suture is transverse; the maxillary suture oblique and gently concave. The superior aspect of each bone is on one plane, sloping outward and forward.

**Nasals.** The nasals are united by well-marked sutures, and are subquadrate in shape, the maxillary and frontal sutures, which are nearly of the same length, meeting in an acute angle. There may have been a slight notch in the middle in front. The bones together form a very gentle arch.

**Premaxillaries.** The premaxillaries show distinct sutures, both median and lateral, the latter nearly at the outer margin of the narial opening and all parallel.

**Postfrontals.** The postfrontals form an extensive arch, together with the parietals, covering the temporal fossæ. Their union with the jugals is not evident, but seems to be above the middle of the posterior orbital margin. The postfronto-squamosal suture is likewise not distinct.

**Maxillaries.** The lower margin of the maxillaries form a rather thin, somewhat sinuous edge. The junction with the jugal it is impossible to trace. On the posterior part from

near the middle of the orbital margin, there was evidently a thin expansion downward, but the edge has been broken off, so that one cannot say to what extent. Its ascending process to join the prefrontals is about one inch in width between the nares and orbits. The **Nares.** external nasal opening is cordate in shape, with a rounded anterior angle. The plane of its margins looks upwards and forwards at an angle of about thirty-five degrees from the perpendicular. The **Orbits.** posterior margin of the orbits is almost exactly in the middle of the anterio-posterior diameter of the skull. Their shape is irregularly oval, the greater diameter being from before back. Their superior margin, as far back as the fronto-postfrontal suture, is parallel with the median line of the skull; it then turns obliquely outward, with a gentle convex border, to the middle of the hind margin. The plane of their margins is not more than ten or twelve degrees from the vertical, and is turned outward and forward at an angle of about thirty-five degrees. The margins are everywhere thin. The man- **Mandible.** dibles have been firmly compressed upon the maxillaries, and are posteriorly somewhat flattened. They are stout and heavy, with a thin inferior margin throughout most of their extent. The genial margin is gently convex and considerably receding. The superior margin was evidently thin, like that opposing it. Their articulating surfaces cannot be clearly made out, as the quadrates have been crowded upon them. They appear, however, to be lightly convex. The two sides show no trace of a suture between them.

**Palatines.** The palate is remarkable for its extreme concavity, and the anterior position of its choanæ. All posterior to the pterygoids has been so crushed that it is impossible to determine the characters.

**Pterygoids.** The pterygoids are short and narrow, concave on the sides, extending out in front to form a rounded, vertical, ectopterygoid process, just in front of which is the distinct, transverse, palatine suture. The palatines continue the full width of the pterygoids in front, and are gently concave, with a rounded margin on the sides as far as the process. These processes curve outward and forward nearly horizontally to unite with the maxillaries, which do not send a distinct process out to meet them. Near the posterior border of the process, well out towards the extremity, there is a small palatine foramen, leading up into the floor of the orbit at about its middle, and vertically below, or a little to the inner side of the innermost part of the superior margin of the orbit. On the left side there appear to be two foramina. Almost from the posterior margin of the palatines the surface begins to ascend obliquely forward, forming a deep channel, which in the anterior half is divided into two by a strong median ridge. Unfortunately the suture with the vomer cannot be made out.

The posterior narial openings are extraordinarily large, and situated far forward, almost immediately below the anterior openings. Each opening is large, and its plane looks upwards, forwards and inwards.

**General characters of the skull.**

The skull is elongate, narrow and high. It tapers on the sides from near the quadrates to the front margin of the orbits, whence the muzzle forms an acute, somewhat convex cone. The superior surface from the front margin of the nasals is only lightly arched, but with a rounded boss back of the middle. The surface is nearly smooth, or with delicate striæ, except near the front end, where it has numerous small, rounded pits. The orbital and nasal margins are sharp.

The principal dimensions of the specimen are as follows:

| | |
|---|---|
| Extreme length | 205 mm. |
| Width through quadrates | 145 |
| Height | 95 |
| Length of mandibles | 155 |
| Width between orbits above | 58 |
| Greatest width between the orbits posteriorly | 105 |
| Antero-posterior diameter of orbits | 60 |
| Width of orbits | 42 |
| Transverse diameter of nares | 31 |
| Antero-posterior diameter of same | 31 |
| Least width of pterygoids | 22 |
| Width through the ectopterygoid processes | 46 |
| Least width of the palatines | 43 |
| Antero-posterior diameter of posterior nares | 24 |
| Transverse diameter of same | 18 |
| Distance between choanae | 16 |
| Width between palatine foramina | 48 |
| Width of mandible through symphysis | 43 |
| Width of mandible below orbit | 24 |

The skull, as will be seen from the description and the figures, has a great resemblance to that of the sea-turtles, the rostrum being somewhat less narrow than in *Chelone*, but from which it differs conspicuously in the presence of free nasals, the presence of palatine foramina, the structure of the palate and the anterior position of the choanæ, and the convexity of the maxillary condyle. Its resemblance to *Rhinochelys*, from the Cambridge Greensand seems greater, so far as I can judge by the figures given by Lydekker. Like that, it has free nasals, the pterygoids narrow and emarginate, the palatines probably meeting in the middle line, the prefrontals separated, the jugal continuing the line of the alveolar border to the quadrate, mandible with the interdentary suture obliterated, and with a prominent oral margin. From it there seem to be ample generic differences. There are no indications of epidermal shields in the present skull.

**Cervical vertebræ.**

The specimen, as I received it, showed crowded into the posterior temporal opening three cervical vertebræ. With much labor one of these has been removed which presents important characters, all distinctly Pleurodiran. The anterior surface of the centrum is markedly convex, but much broader from side to side than from above downward, being subtriangular in shape. The posterior zygapophyses are elongated and evidently arched downward. The arch above is gently convex. Near the posterior part of the centrum on each side is a very stout transverse process. The posterior articular surface of the centrum has been injured, but is convex. The measurements of this vertebra are as follows:

| | | |
|---|---|---|
| Length of centrum from rim to rim | 26 | mm. |
| Width of anterior articular surface | 26 | |
| Vertical diameter of the same | 15 | |
| Width through transverse processes | 64 | |
| Thickness of transverse processes | 17 | |
| Diameter of neural canal, transverse | 13 | |
| " " " " vertical | 14 | |

**Caudal vertebræ.**

Several caudal vertebræ are preserved, one of the largest of which is shown in the plate VI, fig. 4. They are all small, and indicate a small and short tail. The centrum is moderately elongated, with well-developed zygapophyses, and rudimentary transverse processes. The anterior end of the centrum is concave, the posterior convex. Its measurements are as follows:

| | | |
|---|---|---|
| Length of centrum | 17 | mm. |
| Height of vertebra | 22 | |
| Vertical diameter of cup | 12 | |

**Pectoral girdle and extremity.**

The bones of the pectoral girdle and extremity preserved were found so little distorted from their natural position that their mutual relationships are assured. The scapula and coracoid were found between the carapace and plastron near together. A part of the coracoid has been lost, but the inner end was lying in apposition to the inner end of its mate. There is one nearly complete humerus preserved and close to the lower end of both were the bones of the forearm and the metacarpal bones which are figured. Unfortunately, the single bone figured as carpal or tarsal had been separated from the matrix and its position is unknown. The four bones of the metacarpus were lying nearly in position, the two inner ones crossed over each other. Lying across them and undoubtedly belonging with them is the fifth bone.

**Scapula.** (Plate V, fig. 3.)

The scapula-precoracoid is preserved complete, and shows but little distortion or compression. The humeral neck is moderately constricted, and is longer relatively than in *Protostega*. The two extremities are flattened oval in cross-section near the base, with rounded margins. The precoracoid is shorter than the scapula, and is flattened and a little dilated at the distal extremity. The scapula is slightly widened distally, and ends in an obtuse point, with two shallow emarginations before the tip on the inferior border, and one on the upper border, separated by rounded prominences. The angle of the scapula with the precoracoid is a little less than a right angle.

| | | |
|---|---|---|
| Width of neck | 42 | mm. |
| Width of articular extremity | 56 | |
| Length of precoracoid to inferior border of scapula | 82 | |
| Width of precoracoid distally | 34 | |
| Length of scapula to inferior border of precoracoid | 158 | |
| Greatest width of scapula distally | 32 | |
| Least width of scapula | 27 | |
| Distance between extremities of scapula and precoracoid | 175 | |
| Thickness of precoracoid at proximal end | 9 | |

**Coracoid.** (Plate V. fig. 1.)

The coracoid is a remarkably short bone for so large a turtle. The single bone preserved, of the right side, lies immediately above the precoracoid and below the carapace. Its articular end is thickened, with a thinner expansion for articulation with the scapula. The scapular border is deeply concave, the distal extremity thin and moderately expanded. The outer border, except proximally, is wanting, but from the thinness of the border at the extremity, it appears to have been nearly straight.

| | | |
|---|---|---|
| Length | 100 | mm. |
| Width at proximal end | 35 | |
| Width of shaft (approximately) | 18-20 | |

**Humerus.** (Plate IV.)

The humerus is a very large, flat bone, intermediate in some respects between that of *Protostega* and that of *Chelone*, but with a narrower shaft than in either. Both bones were originally present, but unfortunately the left one is represented only by fragments. The distal end is shaped very much as in *Chelone*, save as already stated that it is more constricted above, below the radial process. The radial process is even larger than in *Protostega*, though not reaching as far down the bone. The ulnar process, on the other

hand, is even more elongated than in *Chelone*, and is apparently even longer than I have represented it in the drawing. The bone is in all respects the humerus of a sea-turtle.

| | |
|---|---|
| Length from top of articular surface | 202 mm. |
| Extreme length, about | 260 |
| Greatest diameter of a scapular articular surface | 44 |
| Least width of shaft | 40 |
| Width through lower part of radial crest | 67 |
| Greatest width distally | 80 |
| Thickness of shaft | 17 |

**Radius.** (Plate V, fig. 2.)

Lying nearly in connection with the portion which is preserved of the left humerus, are the nearly complete radius and a portion of the ulna. The radius has been but little compressed, and it is in excellent preservation, save for the part that is lost. Both extremities are expanded, apparently about the same. The upper end is thicker than the lower, and has slight striate markings near the border of the articular surface. About 25 mm. from the upper extremity, near the inner border, there is a roughened protuberance, the bicipital tuberosity. The shaft is quite smooth and oval.

**Carpal?** (Plate VI, fig. 3.)

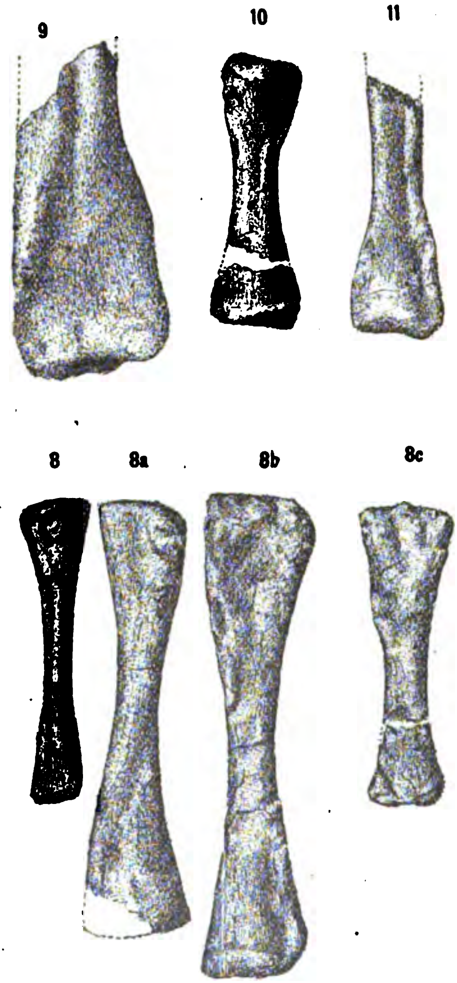
A single bone, which from its size I take to be a carpal and not a tarsal, is very thin and flat, nearly smooth, and oval in shape. It measures 52 mm. in its greatest and 38 mm. in its opposite diameter, and is nowhere over 5 mm. in thickness. It has some very inconspicuous markings near the articular margin.

**Metacarpals.**

The four bones represented in the accompanying figure were lying upon the end of an ulnar fragment, and almost over the radius and nearly in the position in which they are figured, the two inner ones being crossed. That they belong to the manus I have no doubt, and that they are metacarpals and not phalanges seems evident from the shape of their articular ends. Their measurements are as follows:

| | | |
|---|---|---|
| 8. | Length | 48 mm. |
| | Width of distal extremity | 9 |
| 8a. | Length | 87 |
| | Width proximally | 19 |
| | Width distally | 18 |
| 8b. | Length | 55 |
| | Width distally | 20 |
| 8c. | Length | 55 |
| | Width proximally | 15 |

Another finger bone, lying across the end of the radius is shorter than any of the foregoing, and may be a phalanx. One end is want-




*Desmatochelys Lowii*, two-thirds natural size. 8, a, b, c, metacarpals. 9, indet.: 10. phalanx; 11, metacarpal (?).

ing, but the end which is present and the shaft are stouter than any of the foregoing. The width at the end is 22 mm., and in the narrowest place of the shaft 12. Yet another digital bone (fig. 10) seems to be a phalanx, but whether of the fore or hind foot can not be said, as it was misplaced. Its measurements are as follows:

| | |
|---|---|
| Length | 36 mm. |
| Width at extremities | 11, 12 |
| Least width of shaft | 9 |

**Pelvic girdle and extremity.** (Plate VI.)

The three pelvic bones of the right side are lying with their articular surfaces nearly contiguous, the upper end of the ilium in

apposition with the end of the transverse process of the sacrum. On the left side, the ischium and a part of the ilium, also in position are alone represented. Unfortunately of those of the right side the outer end of the ilium and a part of the anterior border of the pubis have been lost. The ilium is an irregular rod of bone, stout and not very broad with a pointed sacral extremity. Its anterior border is deeply concave, smooth and rounded, and not very thick. Its posterior border is dilated into a thinner expansion below, which is turned outward. Near the extremity, however, the bone again forms one plane and is moderately thick.

| | |
|---|---|
| Greatest width of ilium | 35 mm. |
| Width before the acetabular articulation | 26 " |

On the inner margin near the tip, there is a slight roughening, lying in apposition to the tip of the transverse process of a sacral vertebra.

**Ischium** (fig. 1a).

The ischia have a smooth paddle-shaped extremity, a long tooth-like tuberosity, and a dilated articular extremity which shows facets for the ilium and pubis. The symphysial end is broad, nearly straight on its margin, with rounded angles, and moderately thick. The tuberosity, which is situated about the middle of the bone, is conical, pointed and curved toward the acetabulum.

| | |
|---|---|
| Length | 84 mm. |
| Width of symphysial end | 43 |
| Width of acetabular end | 35 |
| Width of shaft on the proximal side of the tuberosity | 21 |
| Length of tuberosity | 25 |

**Pubis** (fig. 1b).

The pubis is much thickened at the acetabular end, expanded and thin at the symphysial end. The side exposed, the inner, shows two facets, separated by a distinct angle. The ischial border is deeply concave, and for the most part thin. The bone is narrowest midway, and the whole lower part is evidently thin. Unfortunately the anterior inferior portion has been lost. The surface exposed is nearly plane throughout, though it probably had some curvature. There are no indications on either pubis or ischium of union with the plastron.

| | |
|---|---|
| Width of acetabular extremity | 37 mm. |
| Length of ischial facet | 25 |
| Length of bone as preserved | 108 |

**Femur.**

The only bone of the hind extremity preserved is an incomplete femur which lies directed backwards, with the great trochanter immediately below the sacral end of the ilium. Its great trochanter is

flattened, high and broad, with distinct rugosities on the outer side. The head is a small oval articular surface surmounting a rather thin small plate placed nearly at right angle to the plane of the trochanter and at one side. Just back or below (?) the head is a distinct depression or "digital" fossa, with a muscular rugosity near it. On the outer, or dorsal convex surface, near the narrowest part of the shaft, there are two roughened surfaces, one on the border opposite to that of the head forming a rounded tubercle about half an inch in diameter. The lower part of the bone is expanded and quite thin.

| | |
|---|---|
| Width of trochanter | 32 mm. |
| Height of trochanter above the head | 25 |
| Height of head above plane of trochanter | 20 |
| Length of articular surface of head | 10 |
| Width | 7 |
| Width of shaft | 25 |
| Thickness of shaft | 12 |
| Width near lower extremity as figured | 40 |
| Thickness | 6 |

**Carapace.**

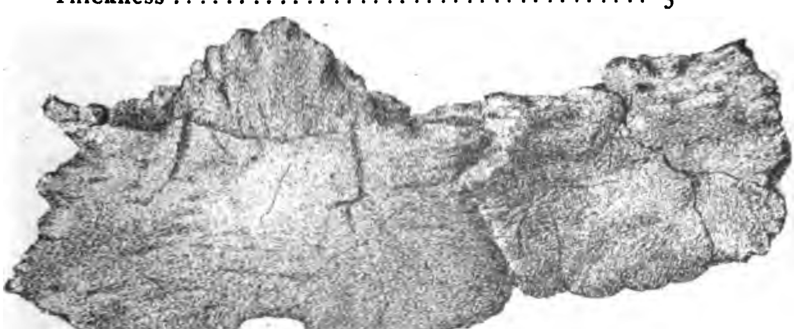
The carapace must have been originally nearly complete, but much has been lost and other portions have been injured in removing the hard matrix. It was evidently narrow in proportion to its length, and was pointed posteriorly. The bone everywhere is very thin, from two to three millimeters in thickness and shows numerous small or minute pits; no other evidence of shields, however, is present. The sutures in some places between the pleuralia and neuralia are distinct, but for the greater part obliterated. The lateral plate corresponding to the third presacral vertebra has a length of 135 mm., but the very thin end is wanting, and may have been prolonged to the marginal. Its width proximally is 40, toward the outer part five or six millimeters more. The neural for this vertebra has its front and lateral sutures distinct; at its broadest part behind it measures 32 mm. in width.

The dorsal vertebræ are stout and cylindrical, with moderate expansions at the extremities. The rib processes are stout, situated near the anterior part of each vertebra and the ribs articulated with one centrum alone in the posterior vertebra at least. The processes and heads of the ribs are stout, and are united by a free suture. The ribs of the three presacral vertebræ exposed are directed very obliquely upward; the transverse processes of the sacrum are nearly horizontal, slender, and the first pair directed a little obliquely backward.

| | | |
|---|---|---|
| Length of second sacral vertebra | 21 | mm. |
| Length of first sacral vertebra | 24 | |
| Width through the articular surfaces for the transverse processes | 31 | |
| Width of transverse process at base | 17 | |
| Width of transverse process distally | 11 | |
| Length of transverse process | 45 | |
| Length of first presacral vertebra | 29 | |
| Width of centrum anteriorly | 22 | |
| Width through rib processes | 25 | |
| Length of second presacral vertebra | 40 | |
| Width of centrum anteriorly | 24 | |
| Width through rib processes | 29 | |
| Distance between inferior margin of same vertebra and the top of the carapace | 40 | " |

Eight marginal bones are present, including the pygal. Whether they are all from the same side or not I do not know; but all are different. Lying in position, with the anterior projection touching nearly the posterior end of the united carapace is the pygal which is figured, the surface which is represented being the upper one, and the attached marginal belonging to the right side. Lying beneath it, near the margin, were two small caudals, one of which is shown in the figure. The pygal and adjacent marginal are very flat bones, very thin on the outer margin, somewhat roughened on the anterior part. A fragment of the attached left marginal is present, but is not shown in the figure. The sutural union, here as elsewhere is firm.

| | | |
|---|---|---|
| Length of pygal | 97 | mm. |
| Width at the ends | 42 | " |
| Width across the middle | 61 | " |
| Thickness near anterior border | 6 | " |
| Length of adjacent marginal | 64 | " |
| Width | 45 | " |
| Thickness | 5 | " |



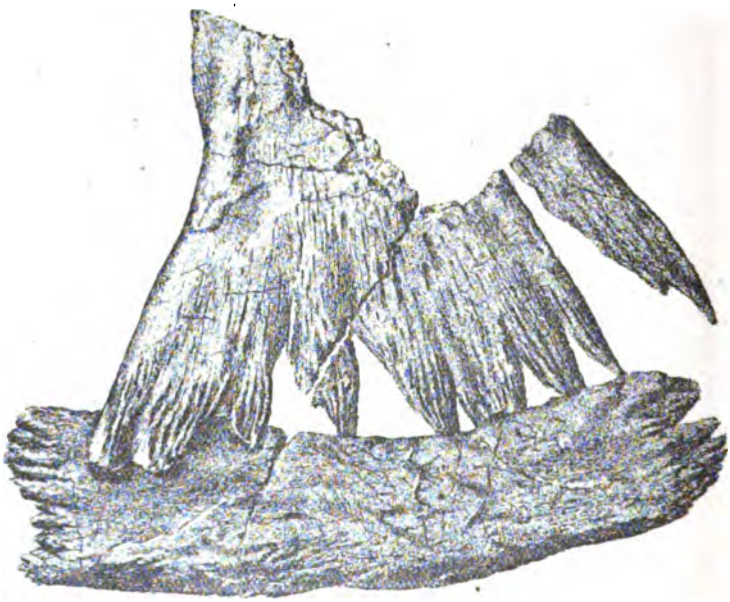
Pygal and contiguous right marginal of *Desmatochelys Lowii*, two-thirds natural size.

Lying in contact with a hyo- or hypoplastron is one complete marginal, and portions of two others partly detached. The bones

here are elongate and narrow, with interdigitated sutural ends. On the lower side of the one exposed they are flat, with the inner margin thin, but somewhat thickened on the outer part.

| | | |
|---|---|---|
| Length of lateral marginal | 130 | mm. |
| Width at one end | 35 | |
| Width at other end | 27 | |
| Width of contiguous marginal | 37 | |
| Thickness near middle | 6 | |

The half of two contiguous marginals lying over the left scapula show the outer part thicker, from nine to eleven mm. in thickness, the inner part very thin, and, near the middle, below the thin border a shallow horizontal pit, which may have been for the reception of a rib. The greatest width of these bones is 39 mm.



Lateral marginal and adjacent plastral bone of *Dermatochelys Lowii*, two-thirds natural size.

**Plastron.**

All the plastron was originally preserved, but part has been lost, and some has been necessarily injured or destroyed in getting at the bones lying between it and the carapace in the hard matrix. Lying contiguous with the upper end of the right humerus is a large, thin, flat bone which is evidently the epiplastron. The bone had sustained injuries or decomposition before fossilization, or was of a partly cartilaginous nature. Its thicker, rounded border is gently concave and measures a little over 200 mm. in length. Lying upon it and impressed as though partly pressed into its substance, is evidently

another bone, which agrees better with the epiplastron of Chelone. It is gently convex on the outer, concave on the inner border, tapering to a point from the flat blade, and with well-marked longitudinal grooves upon it. It measures 180 mm. in length and has a width on the outer part of nearly 30 mm. If this is the real epiplastron, I do not know what the broad bone is.

A number of fragments of the hyo- or hypoplastron are present, but, unfortunately, the portion figured cannot be united to the remainder, through the loss of intermediate portions. That they all belong to one bone seems evident from the marked peculiarities in the surface, color, and markings. The anterior (?) denticulate margin has a width of 90 mm.; the posterior hypoplastral border (?) is incomplete, was not more than 60 mm. in width and could not have had a close union with the hypoplastron, if it touched it at all, as the extreme length in this direction is only about 200 mm. The bone is thicker and of firmer texture than is the carapace. The posterior end of the xiphiplastron lies under the sacrum. It is only 30 mm. in width, is thin and has four elongated denticulations. The whole structure of the plastron appears to have been something like that in *Protosphargis veronensis.* Whether the other elements of the plastron were present or not, I cannot now say.

**Systematic position.**

All things considered, I believe that the genus *Desmatochelys* must be located among the *Cryptodira,* in a distinct family of Baur's *Chelonioidea.* But this will necessitate revision of the characters hitherto attributed to both suborder and group. These may best be expressed by giving the characters in detail, as Baur* has expressed them, with the emendations shown in italics.

**Cryptodira.**

*Free nasals sometimes present,* a parieto-squamosal arch present or absent; descending process of prefrontals connected with vomer; stapes in an open groove of the quadrate or covered by the quadrate behind; pterygoids narrow in the middle, without winglike lateral expansions, separating quadrate and basisphenoid; epipterygoid free or not free; dentary bones united. *Cervical vertebræ rarely with stout transverse processes;* the posterior cervicals with double or *single* articular faces; sacral ribs well developed and connected with centrum and neuroids; Pelvis free from plastron, and free *or not* from carapace. Epiplastra in contact with hyoplastra; entoplastron oval, rhomboidal or T-shaped, a more or less complete series of peripheralia more or less connected with the ribs, *or free.*

*Note on the Classification of the Cryptodira. Amer. Naturalist. July 1893, p. 672.

I.—*Chelonioidea.* A parieto-squamosal arch; articular faces between sixth and seventh cervical vertebræ plane, nuchal with a distinct process on the lower side for the articulation with the neuroid of the eighth cervical; no lateral processes of nuchal. One biconvex cervical vertebra.

1.—*Desmatochelyidæ.* Palatine foramina present, a descending process of the parietals; free nasals present; limbs paddle-shaped. *Desmatochelys.*

2.—*Cheloniidæ.* Palatine foramina not present; a descending process of the parietals; no free nasals; limbs paddle-shaped; claws one or two. *Chelone*, etc.

3.—*Dermochelyidæ.* No free nasals, no palatine foramina; no descending process of the parietals; no claws; limbs paddle-shaped. Bony carapace dissolved into numerous mosaic-like pieces. *Dermochelys.*

Of course a more perfect knowledge of *Desmatochelys* may necessitate a yet further revision of the different group-characters.

LAWRENCE, May 5, '94.

# Notes on Uintacrinus socialis Grinnell.

While a member of the late Professor Mudge's party in western Kansas, during the summer of 1875, the writer was fortunate in finding in the Niobrara chalk a number of specimens of a crinoid which were notable from their very rarity. During that same season, whether before or after I do not now remember, other specimens of the same kind were discovered by Prof. Mudge and Mr. Geo. Cooper, all of which, as well as those found by myself, had been more or less exposed and weathered. A very few of these found their way into different collections, and among them were those which serve as the types of genus and species.* An imperfect specimen of this genus had been previously discovered by Marsh in the Uinta Mountains, but so incomplete that its affinities could not be decisively made out. ("In a stratum of yellow calcareous shale which overlies the coal series conformably, a thin layer was found full of *Ostrea congesta* Conrad, a typical Cretaceous fossil; and, just above, a new and very interesting crinoid, allied apparently to the *Marsupites* of the English chalk." Marsh, Amer. Journ. Sci., March, 1871.) Because of this previous discovery, the generic name was chosen, but there is no proof that the species, at least, are identical.

During the season of 1891, Prof. E. E. Slosson, while a member of the Kansas University expedition in western Kansas, was so fortunate as to discover a most remarkable colony of this crinoid, by far the best yet known, in the vicinity of Elkader, on the Smoky Hill river. While all the colonies hitherto discovered have been exposed and more or less weathered, the present one was found in position, covered by the soft blue shale. The animals had lived so closely together that their very long arms had become inextricably entangled, and, by consolidation, had formed a dense calcareous plate, about one-third of an inch in thickness in the middle of the plate, but thinning out at the margin. About one-half of the thin slab as thus formed had been washed away; the remainder, as now restored in the University Museum, measures about six feet by three or four, and has, upon its under side, nearly one hundred of the crinoids, the greater part of which are perfectly preserved. The calyces all lie flattened out, showing, in some cases, the basal plates, but, as might be expected, never the upper or ventral portions. The inter-

*Grinnell, Amer. Journ. Sci. xii. 81, July, 1876.

lacing of the arms prevents the tracing of any to the extremity. A photograph of a portion of the slab will be given in a future number of the QUARTERLY; for the present, the following description and figure, by Mr. B. H. Hill, student in paleontology in the University, will be of interest.

The horizon of *Uintacrinus* in Kansas seems to be confined to near the middle of the Niobrara. All the specimens hitherto discovered, of which I have any knowledge, have come from the vicinity of Elkader on the Smoky Hill, though in all probability, they will be found on both the Solomon and Saline.

S. W. WILLISTON.

In life, *Uintacrinus socialis* was evidently subglobose in shape, and about two inches in diameter. In place of the sub-basal plates of the stemmed crinoids, there is a small, five-sided, centro-dorsal plate, around which are grouped five pentagonal basals, the two

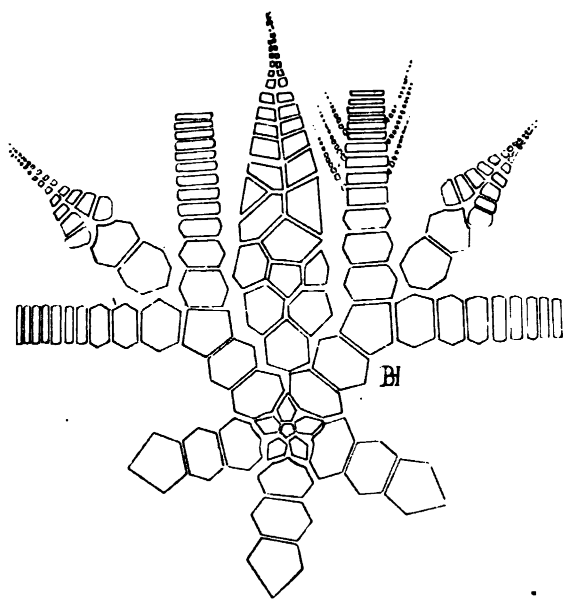



Diagram of *Uintacrinus socialis* Grinnell.

longest sides of which meet in a superior angle. The radials are fifteen in number, arranged in series of three. The first radial is the broadest, broader than high, heptagonal in shape, the third pentagonal. The two superior facets of the third radials give support to two series of secondary radials, the proximal three of which are its supports. The arm plates are thin and round, and radiate in structure. The arms themselves are ten in number. In

the colony there is one arm which I have traced for seventeen inches, and a comparison of its last distinguishable plates with the terminal ones of the other arms makes it evident that the arms must have been over two feet in length, as stated by Grinnell. They have well-developed pinnulæ beginning at the base of the arm, where they are very large. They arise one from each plate, but alternating on the two sides of the ambulacral groove. Grinnell described what he believed to be interbrachial and interradial arms, but it seems certain that he was in error in this respect, having mistaken the pinnulæ for these arms. The interradials are usually seven in number. The first is hexagonal and lies between the first and second radials of two series. The other six are also hexagonal, and in life may have been arranged in pairs, but are preserved in the specimens in irregular groups of four. The interbrachials are two in number, heptagonal in shape, and lie, respectively, between the first and second, and the second and third secondary radials of the two arms.

From the shape of the crinoid, its globose form and long, heavy arms, one would hardly expect to find any of the ventral plates exposed, and such is the case. Nor has it been possible to expose them by dissecting away the plates.

B. H. HILL.

# Restoration of Platygonus.

BY S. W. WILLISTON.

(With Plates VII and VIII.)

A short time ago, in an excavation made at the town of Goodland, in the extreme western part of the state, north of Ft. Wallace, a number of fossil bones were found in such orderly preservation that the proprietor of the brick yard in which they occurred, Mr. J. T. Halstead, became interested in the discovery and took measures for their preservation. A number of the bones were sent to the University for identification, and, recognizing a new or unusual animal for Kansas, I immediately went to Goodland and secured the remainder for the University. They were found about nine feet below the surface, in a loose, sandy marl, lying closely together, as though a herd of the animals had been overcome by some sudden catastrophe. In all, nine animals have been uncovered, all lying close together with with the heads directed toward the southwest, the heads of the hinder ones lying upon the posterior parts of the more anterior ones, and the bones all or nearly all in the position in which they had been at the animals' death. Because of this fact, it is very probable that the different individuals had all or nearly all belonged to one herd, and had died at the same time. As will be seen, the animals were of different ages and sexes, presenting characters which might have been accredited with specific valuation had they been found isolated and in different localities. The bones were received at Lawrence mostly complete and by immersion in a dilute solution of glue have been made sufficiently strong to mount in the manner of recent skeletons. This has been done by my assistant, Mr. Overton, with the skeleton of one adult female, and a photograph of the mounted specimen is shown in an accompanying plate.

The age of the deposit in which the bones were found is clearly Pliocene, and from one hundred to one hundred and twenty-five feet above the base of the Loup Fork beds.

The genus to which the species belongs is *Platygonus*, founded by Leconte in 1848 upon fragments of the skull and portions of the metapodials and humerus. Leidy has since added very materially to our knowledge of the genus, still some very important characters have hitherto been undetected. The described species are as follows:

**Platygonus compressus** Leconte, Amer. Journ. Sci. (2), v, 103, Jan., 1848: Mem. Amer. Acad., New Ser. iii, 259-274, pls. i-iv, 1848: Proc. Acad. Nat. Sc. Phil. Jan. 1852, p. 4; Leidy, Trans Amer. Phil. Soc. (2) x, 324-343. pls. 35-38, 1852; Trans. Wagner Free Ins. ii, 41-50, pl. viii, f. 1; Cope. Proc. Am. Phil. Soc. 1885, 15; Wortman, Rep. Ind. Geol. Surv. 1887. *Euchoerus macrops* Leidy, Trans Amer. Phil. Soc. (2), 340, pl. 35, 1852. *Protochœrus prismaticus* Leconte, Amer. Journ. Sc. (2), v, 105; Proc. Acad. Nat. Sc vi, 5; Leidy, Trans. Amer. Phil. Soc. x, 339, 1852.

**P. Ziegleri** Marsh, Amer. Journ. Sci. ii, July, 1871, Grizzly Buttes, Wyo.

**P. striatus** Marsh, Amer. Journ. Sci. July, 1871. Pliocene, Nebr.

? **P. Condoni** Marsh, l. c. Pliocene, Oregon.

**P. vetus** Leidy, Proc. Phil. Acad. Nat. Sc., 1882, p. 301. Penna.

*P. alemanni* Duges, La Naturaleza, 1887, p. 16, pl. i, ii. Mexico (Leidy, Trans. Wagner Free Ins. ii, p. 40).

**P. bicalcaratus** Cope, Ann. Rep. Geol. Surv. Texas for 1892, pp. 68, 69, pl. xiii, f. 5. Blanco Beds, Texas.

Of *P. Ziegleri*, the type specimen comprises the upper premolars only, and the species is based upon "the remarkably strong basal ridge, which on the inner border at least of the first and second premolars exceeds in breadth that in *Platygonus compressus* Leconte, although on the posterior margin it is less well developed than in that species."

*P. striatus* is based upon yet more uncertain evidence, the second left lower premolar. "The enamel is marked by delicate irregular striæ, mostly parallel with the base of the crown," a character not found in our specimens.

*P. Condoni* is based upon the three upper molars and is doubtfully referred to this genus by the author. The length of the last upper molar precludes the probability of identity.

*P. vetus* Leidy was based upon two jaw fragments with teeth. "The jaw below the position of the first molar is thick and shallow; below the last tooth it abruptly deepens, and a short distance back it is nearly double the depth. The upper teeth exhibit a well produced basal ridge fore and aft, but none laterally, except the feeble elements of it between the lobes of the crown." Measurements will be found further on.

*P. bicalcaratus* Cope is based upon the posterior part of a last lower molar, and the base of the canines. The molar differs in having not one, but two distinct cusps on the heel.

A species from the Loup Fork Beds of Nebraska figured and described by Scott in the Bulletin of Mus. Comp. Zool. xx, 76, and referred to *Dicotyles* without name, must rather belong in *Platygonus* from the simpler structure of the premolar.

The only species then with which our specimens can be compared is the original, *P. compressus* Lec., which has been found in Virginia, Kentucky, Pennsylvania, New York, Iowa and Missouri, so far as the fragmentary specimens indicate.

The species are certainly closely allied, as a careful study of Leidy's late paper assures me, yet there are certain differences which seem to be remarkable if they are only individual. In any event the abundant material at my disposal, more than all previously known in the genus, and all certainly belonging to one species, will merit a minute comparison and description. The best material so far described as belonging to the species is the young skull from Kentucky described at length by Leidy, and the two adult female skulls described and figured by the same author in his latest paper.

In the present collection there are two young skulls, of nearly or quite the same age as that described by Leidy as *Euchoerus macrops*, and they show the following differences:

The alveolar process for the inferior incisors is more projecting, the diastema between the outer incisor and the canine being eleven millimeters in length, while in the figure it is represented as almost nothing, the incisor coming close up to the canine. The chin is more convex and protuberant in our specimens. The post-canine diastema is shorter, and the jaw much more robust in this region, the lower margin is less straight, and the coronoid process not as high. In the cranium the face is broader, the front less convex the external meatus is situated less far back. In the present species, the sagittal border is parallel or slightly ascending from the plane of the molar contact, while in *macrops* the crest is in a plane markedly descending. On the under side the difference is equally apparent in the more slender facial portion of Leidy's specimen. From the top view the same marked slenderness is seen. In our skulls of the same age the face is more suddenly contracted just back of the most anterior part of the molar suture. There is no *cul de sac*, such as Leidy describes and figures, below the anterior margin of the posterior nares, but, in its place, there is a concavity, above the more convex portion which takes the place of the sharp crescentic ridge. In the lower molars there is no indication of a basal ridge between the transverse ridges, and the anterior and posterior basal ridges are narrower. While there is a distinct heel-cusp to the second lower molar in our skulls, the sharp ridge from the outer cusp behind runs straight to the apex of the heel prominence and does not have an incision. In the third molar, the last cusp is smaller, about as large as it is in the preceding molar of *macrops*, and the ridge connecting it from the preceding outer cusp is incised about as it is in that tooth, and the outer side is rounded, not angular.

The differences from the adult skull, as will be seen in the figures, consists in the greater flatness and straightness of the frontal and parietal region, the more projecting incisor alveoli, the more vertical

and narrower ramus of the lower jaw, the less anteriorly produced flange of the angle, the greater depth below the molars, the more protuberant chin, etc. However, a more accurate idea of the differences or resemblances will be obtained by the comparison of the measurements given by Leidy. In the following table I give in the first two columns the measurements of Leidy's adult (1) and young (2); in the third those of an adult female of our specimens (3); in the fourth of an adult male (4); in the fifth and sixth of young skulls (5, 6); and in the last two (7, 8) those of the oldest skulls in the collection:

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Length of skull from top of inion to end of nasals in median line | 292 | 304 | 294 | 294 | 315 | 304 | .. | .. |
| Length from anterior margin of foramen magnum to end of premaxillaries | 268 | 275 | 260 | .. | .. | .. | .. | .. |
| Breadth at postorbital processes | 15 | 113 | 109 | 100 | 115 | 127 | 128 | .. |
| Breadth of face at middle of zygomas | 135 | 123 | 132 | 105 | .. | 163 | 135 | .. |
| " " " lachrymal eminences | 103 | 93 | 94 | 79 | 85 | 113 | 100 | .. |
| Height of supraorbital margin from a level | 105 | 108 | 115 | 78 | 100 | 113 | 111 | .. |
| Height of face at infraorbital foramen | 82 | .. | 84 | 65 | .. | .. | 82 | .. |
| Height of face at middle of canines | 63 | .. | 58 | .. | 54 | .. | 60 | .. |
| Width of face at first premolar | 38 | 36 | 40 | 40 | 40 | 42 | 44 | .. |
| Width of face at canine alveoli | 69 | 58 | 74 | 55 | 59 | 89 | 75 | .. |
| Width of premaxillaries | 29 | 33 | 49 | 43 | 45 | 52 | 45 | .. |
| Depth of zygoma from end of postorbital process to end of preglenoid process | 69 | 62 | 68 | 52 | .. | 75 | 76 | .. |
| Depth of zygoma at middle below the orbit | 36 | 32 | 32 | 32 | .. | 53 | 40 | .. |
| Length of temporal fossæ from inion to postorbital process | 80 | 80 | 82 | 77 | 80 | 75 | 82 | .. |
| Height of inion | 94 | 89 | 80 | 85 | 71 | .. | .. | .. |
| Breadth of upper part of inion | 60 | 54 | 55 | 52 | 58 | 67 | 57 | .. |
| Breadth at the glenoid fossæ | 125 | 116 | 127 | 112 | 122 | 140 | 126 | .. |
| Height of occipital foramen | 28 | 27 | .. | 25 | 22 | 20 | .. | .. |
| Breadth of occipital foramen | 26 | 26 | 26 | 23 | 21 | 26 | .. | .. |
| Distance between the ends of the paroccipital processes | 50 | 52 | 56 | 56 | 49 | 60 | .. | .. |
| Width between the molars of the two sides | 21 | 21 | 22 | 22 | 24 | 26 | 24 | .. |
| Length of molar series | 73 | 80 | 75 | .. | 71 | 71* | 80 | .. |
| Length of hiatus in advance of latter | 44 | 48 | 52 | 45 | 46 | 47 | 52 | .. |
| Height of canine tuberosity | 39 | 30 | 44 | 26 | 31 | 48 | 40 | .. |
| Length of mandible from condyle to symphysis | 220 | 223 | 226 | 197 | 215 | 220 | 232 | 222 |
| Height of mandible at the condyle | 74 | 74 | 96 | 84 | 81 | 120 | 95 | 98 |
| Height of mandible at the coronoid process | 82 | 84 | 110 | 90 | 88 | 125 | 104 | 106 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Depth of mandible below the premolars | 36 | 37 | 45 | 35 | 40 | 49 | 44 | 47 |
| Depth obliquely at the symphysis | 78 | 73 | 78 | 62 | 66 | 78 | 79 | 74 |
| Width at the canine alveoli | 36 | 35 | 39 | 32 | 32 | 40 | 43 | 38 |
| Length of the lower molar series | 78 | 82 | 80 | .. | 82 | 75 | 81 | 80 |
| *First premolar undeveloped. | | | | | | | | |
| Length of the hiatus in advance | 52 | 54 | 54 | .. | 45 | 58 | 59 | 54 |
| Transverse diameter of the condyle | 24 | 23 | 25 | .. | 22 | 30 | 28 | 26 |

If they all pertain to one species, the figures will at least show the extraordinary variations to which the species is liable. Perhaps the most important differences are those of the lower jaws. The corresponding measurements of the type of *P. alemanni* Dugés, given by Leidy, are as follows:

| | |
|---|---|
| Height of mandible at condyle | 100 |
| Height of mandible at coronoid process | 104 |
| Depth of premolars | 45 |
| Space occupied by the molar series | 91 |
| Length of hiatus in advance of molars | 62 |
| Breadth of condyle | 33 |

Leidy says "The mandible with the lower teeth is an amplified repetition of that of *Platygonus compressus* and appears to differ only in the less backward position of the condyle, which in this direction is less than the angle, as (it is) in the Peccaries." As will be seen from the measurements, the jaw of *P. alemanni* is actually smaller than the largest of our specimens, while the position of the condyle does not differ. The size of the teeth only is different. As from the comparison of the types Leidy thought that the species was the same as *P. vetus*, our specimens seem to unite all three.

I confess my inability to decide whether or not these species are independent. A careful comparison of all the known material in the genus will I think be necessary for this purpose. Meanwhile, I will use the name *P. leptorhinus* for the present specimens.

For further comparison, I give below comparative measurements of other bones of the skeleton, those in the first column taken from Leidy, the other two from our specimens. The bones whose measurements are given in the third column belong to the male skull figured; those in the second column are taken from the mounted skeleton. The figures in the last column are of *P alemanni.*

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Humerus, extreme length from greater tuberosity to outer condyle | 190 | 200 | 222 | |
| Length from head to posterior process of inner condyle | 168 | 167 | 173 | .. |
| Greatest breadth of proximal extremity | 57 | 65 | 67 | .. |
| Greatest breadth of head | 33 | 39 | 39 | .. |
| Greatest breadth of distal extremity | 39 | 42 | 44 | .. |

| | | | | |
|---|---|---|---|---|
| Greatest breadth of distal articulation | 30 | 32 | 35 | .. |
| Ulna, extreme length | 214 | 212 | 215 | .. |
| Radius, extreme length | 156 | 158 | 172 | .. |
| Breadth of proximal articulation | 29 | 31 | 35 | .. |
| Ulna and radius, breadth of distal extremity | 36 | 44 | 42 | .. |
| Femur, extreme length head to inner condyle | 193 | 195 | 205 | .. |
| Diameter of head, fore and aft | 27 | 20 | 32 | .. |
| Diameter of head, transversely | 32 | 34 | 35 | .. |
| Breadth of condyles | 46 | 50 | 54 | .. |
| Breadth of trochlea | 21 | 24 | 25 | .. |
| Tibia, extreme length internally | 196 | 196 | .. | .. |
| Breadth of proximal extremity | 46 | 46 | 46 | .. |
| Breadth distal extremity | 28 | 35 | .. | .. |
| Metacarpals, extreme length | 93 | 90 | 95 | .. |
| Breadth proximal articulation | 31 | 38 | 38 | .. |
| Breadth distal extremity | 30 | 36 | 36 | .. |
| Metatarsals, extreme length | 100 | 100 | 102 | 110 |
| Breadth proximal articulation | 27 | 32 | 32 | .. |
| Scapula, length along posterior border | 184 | 175 | 180 | .. |
| Greater width of glenoid articulation | 23 | 30 | 30 | .. |
| First thoracic vertebra, length from anterior inferior margin of centrum to end of spinous process | 146 | 166 | .. | .. |
| Length of centrum | 24 | 26 | .. | .. |
| Lumbar vertebra, extreme height | 66 | 69 | 72 | .. |
| Length of centrum | 34 | 37 | 38 | .. |
| Sacrum, length at middle | 120 | 127 | 120 | .. |
| Breadth at base | 83 | 90 | 83 | .. |
| Breadth of lumbar articulation | 33 | 38 | 35 | .. |
| Breadth of posterior extremity | 30 | 41 | 32 | .. |
| Breadth of coccygial articulation | 18 | 28 | 17 | .. |
| Innominatum, extreme length | 233 | 220 | .. | .. |
| Extent of pubic symphysis | 68 | .. | 72 | .. |
| Diameter of acetabulum | 33 | 38 | 36 | .. |
| Astragulus, extreme length | 43 | 40 | 44 | 44 |
| Calcaneum, extreme length | 76 | 78 | 82 | 85 |

Comparative measurements of the teeth will be found further on. In the following description of the skulls I have used for comparison the corresponding parts of *Dicotyles torquatus*. Leidy gives the chief differences of the adult skull of *P. compressus* from *D. labiatus* in his latest paper, to which the reader is referred.

**Skull of adult female.**

The skull differs markedly from that of *Dicotyles torquatus* in its more elongate and contracted facial portion, in the broader and flatter frontal region, the more prominent, much broader and stouter zygomatic arches, in the smaller incisors, the stouter process for the reception of the superior canines, the longer post-canine diastema, the greater acclivity of the sphenoid, etc.

The palate is somewhat more deeply concave in front, and more roughened on the side. Posteriorly, in place of the fossa, which is narrowed posteriorly into a slender grove in *Dicotyles*, there is an acclivity ending in a shallow, broad groove, which soon becomes steep to the margin of the posterior nares, which are situated much higher up. The pterygoid plate, instead of contracting so that the small pterygoid processes are nearly in contact, pass nearly straight backwards, and a little outward to the tympanic bullæ. They do not have a reflected margin posteriorly, and the notch for the carotid foramen is smaller. The result is that the inferior opening for the nares is not cordiform, but is elongate, much broader and much deeper. The sphenoid turns upward, almost at a right angle with the basilar process, which has at its anterior angles prominent tuberosities. The tympanic bullæ are nearly as in *Dicotyles*, but the basioccipital between them is nearly horizontal, and the glenoid processes are turned obliquely outward and forward, with the articular surface further below their level. The paroccipital processes are a little longer, and the condyles are placed more below the plane of the bullæ. Just in front of the condyles there is a much deeper depression on each side of the middle. The glenoid surfaces are less elongate, and directed more antero-posteriorly. The post-glenoid processes do not differ, but are located further out from the antero-posterior line of the molars. The foramen magnum is more oval, the occipital surface steeper. The diastema between the premolars and the canines is much longer in *Platygonus*, being equal to nearly two-thirds of the length of the cheek teeth, while in *Dicotyles* it is not more than one-third of the length. The distance between the canines is proportionally greater, while the proportion of the face in front of the canines is much smaller. The incisors are much smaller, especially the outer one, which is feebly developed. The anterior palatine foramina, situated almost wholly within the premaxillæ, are smaller. The lateral borders of the premaxillæ above are broader and more divergent, and the superior process extends backward nearly as far as the first premolar tooth. The anterior nasal opening is more transverse, and more open, narrowed above, with the lateral vacuity reaching farther back, as far as the top of the canine tuberosity. The nasals on the distal half are not convex above transversely, or gently flattened, but have a distinct, shallow groove; they terminate in front in an elongate narrow process, and not almost in a right angle, as in *Dicotyles*. They are more elongate, tapering gradually from their origin, and are less convex on the upper part. The groove on the sides is about as it is in *Dicotyles*, the foramen in which it terminates being about opposite the fronto-nasal suture. The frontal and ante-

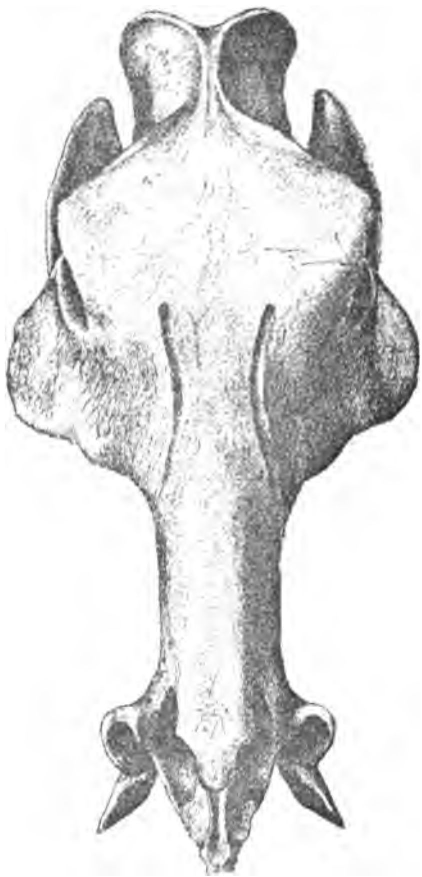
rior parietal region is broad and transverse and nearly flat, the upper orbital margins being as high as the intervening portion. The posterior orbital process is more projecting. The temporal ridges meet in a very obtuse angle, as much greater than a right angle as it is less in *Dicotyles*. The transverse diameter of the brain cavity in front is almost exactly the same as in the adult skull of *D. torquatus*, indicating a brain of relatively less capacity in the *Platygonus*. The sagittal crest is longer in *Platygonus*, and the constriction in front of the lateral wings of the occiput decidedly less; the tentorium seems to be better developed. The ascending process of the squamosal, over the external auditory meatus, is more nearly vertical, placed nearer to the cranial wall, and with a more constricted and more sinuous notch between it and the lateral occipital wings. The malar is thicker, stouter and broader, and has the masseter ridge arching up on its outer side to the base of the orbital process. Anteriorly, the malar ridge is not continued on the side of the face, as is so conspicuously the case in the peccary, but ends in a convex surface above the hind part of the infraorbital foramen. The side of the face is thus much less deeply excavated and is broader than in *Dicotyles*. The infraorbital foramen is situated a little further back and has two small, deep fossæ above it, the one a little in front, the other behind it.

In the lower jaw the condyles have a greater antero-posterior diameter, being, on the inner side, almost as great as the transverse diameter. The coronoid process is no stouter or higher, but is more rounded, and is rather more inflected, with the fossa on the outer side deeper and bounded by sharper and stouter ridges. The flange at the angle is longer from before back, and the under margin of the jaw is less concave in front of it. The inferior border of the body of the jaw is straighter, and the depth below the teeth is relatively less. The post-canine diastema, as in the upper jaw, is much longer, the canines are more slender, not grooved on the sides, and relatively not so long. The chin has a prominence in the middle, giving a strongly convex and less receding profile. The incisors are much smaller, and wholly lack, in all the specimens, the lateral one—there being but two in the lower jaw. The projecting flange at the angle of the jaw is turned outward in its anterior part, not inflected as in *Dicotyles*.

As a whole, the skull has the upper surface straightened, with a gentle convexity over the nasal region. The orbits are situated further back relatively, the chin is more rounded below, etc.

**Skull of adult male.**

The adult male skull differs very strongly from that of the adult female, in the more prominent margins to the temporal fossæ, in the greater convexity of the front, in the narrower and deeper sinus between the squamosal and the malar, in the more nearly closed orbit, and especially in the strongly projecting inferior border of the malar bone over the masseter fossa, recalling the elongated process in the same region in *Elotherium*, which one might suspect is more or less of a sexual character. The canines are stouter and more divaricate, and the "prenasal" bone continues the mesethemoid without distinct suture into a stout, thick ossification, forming a conical protuberance in front of the incisor teeth. In the lower jaw, the most noticeable peculiarity is the much stronger and more protuberant flange, with its sharper anterior angle.



*P. leptorhinus* W. skull of adult male, frontal aspect, one-third natural size.

**Skull of young.**

The skull of the young animal differs, as would be supposed, in its less angular projections. The temporal ridges are rounded, and the sagittal portion is shorter. The zygomatic arches are more nearly vertical in position, and the fossa for the masseter is but little impressed, without the projecting ridge of bone above it, so prominent in the male, and distinctly indicated in the female. The glenoid surfaces are more nearly as they are in *Dicotyles*, and the post-canine diastema, both above and below, is relatively shorter. The milk molars of the lower jaw are more elongated than the true molars. The order in which the permanent teeth were cut appears to be *m1*, *m2*, *m3*, *pm3*, *pm2*, *pm1*.

**Deciduous dentition.**

The lower molars are compressed and elongate, and the cusps are prominent. The first two are nearly alike, with a single ridge, the two elongated cusps of which are united nearly to the apex, and with a groove between them in front. The inner cusp of the first molar is situated a little in advance of the outer. The apex of the cones of both stand a little in advance of the union of the two roots. The posterior basal ridge is broader than the anterior, and, like that, has minute tubercles. The third molar has three ridges, the middle one standing over the arch between the two roots. Their confluent cusps do not differ from those of the preceding ridges, save that their base antero-posteriorly is a little narrower, and the deeper groove between the apices of the third is behind; the first ridge has a small low tubercle in front of the middle, united with the ridge; the anterior basal ridge in front is very narrow, while that behind is only a little broader; there is no lateral ridge at the base of the transverse ridges.

*P. leptorhinus* W. Milk molars and first permanent molar

Lower molars.

The upper molars are decidedly broader than the lower molars, and have a very distinct lateral basal ridge. The first two are distinctly broader in front than behind, and the cusps of all the ridges are separated by a deeper interval from each other, the cusps themselves scarcely differing in height. The two cusps of the first molar have each a rather sharp ridge running upward and forward to near the edge of the basal ridges; behind, the outer cusp only has a similar ridge which curves upwards and inwards to the end near the middle of the basal portion, at a little distance from the edge. The cusps of the two pairs of ridges of the second molar are simple cones or pyramids, with a moderately deep notch between them, and with a deep valley between the ridges. The basal margin in front is a trifle broader than that behind, and the anterior ridge is distinctly shorter than the posterior one. The third molar differs but little from the second, except that the outline is more nearly square, and the anterior ridge is as long as the posterior one.

The canines both above and below are similar, elongate, and less broad than the newly erupted successors; they are smooth throughout, and everywhere nearly uniformly oval in outline.

The incisors have the worn surface more nearly vertical than their successors.

| | |
|---|---|
| Length of first inferior milk molar | 8.5 mm. |
| Width of same | 5 |
| Height of crown | 5 |
| Length of second milk molar | 10 |
| Width of same posteriorly | 6 |
| Length of third milk molar | 19 |
| Width of same through first ridge | 8 |
| Width of same through third ridge | 9 |
| Depth of posterior valley | 5 |
| Distance between the apices of the two posterior outer cusps | 6 |
| Length of first upper milk molar | 9 |
| Width of same over middle of anterior root | 6 |
| Width over middle of posterior root | 8 |
| Length of second upper milk molar | 13 |
| Width of same anteriorly | 8 |
| Width posteriorly | 10 |
| Length of third upper milk molor | 13 |
| Width of same | 11 |
| Length of crown, lower canine | 19 |
| Antero-posterior diameter of same at base | 5 |
| Length of crown, upper canine | 25 |
| Antero-posterior diameter of same at base | 7 |
| Transverse diameter at base | 5 |

**Permanent dentition.**

The unworn first lower molar of the permanent dentition shows a great resemblance in its cusps to those of the last milk molar. The cusps are very high, and the valley between the two ridges narrow and deep. The outer and inner margins of the cusps are nearly vertical, and have no ridges whatever at their base, except a very slight one at the inner side of the posterior ridge. The opposed surfaces of the valley are nearly flat. The angular incision of the second pair is behind, and has, on the outer side, a rather prominent sharp ridge. The outer cusps are slightly higher than the inner ones.

The second lower molar has the apices of the cusps more approximated transversely, at the expense of the inner surface. The anterior inner cusp sends a ridge downward and outward, on each side of which there is a narrow depression back of a slight tubercle, whose walls have a finely wrinkled appearance. The outer posterior cusp sends a similar but stouter, sharp ridge downward and inward to end in the inner hind margin near its middle, on either side of which the margin slopes rapidly away, enclosing a narrow deep pit, like those in front, and marked in the same way. The valley between the two ridges has a high and narrow transverse ridge in the middle, running from the outer posterior cusp.

The third lower molar has the cusps yet more approximated transversely at their apices, and the ridge across the valley is higher and

sharper. The outer posterior cusp sends a similar ridge to connect with a heel-cusp. This posterior cusp is much lower than the preceding cusps, is simple, that is, it has no subordinate cusps, but is convex outwards and posteriorly, and forms an ascending marginal ridge to the inner side. Its highest point is situated very nearly in the middle of the tooth transversely. Between the two cusps of the first ridge in front and behind, there is a minute cusp, the posterior one uniting with the ridges running from the posterior outer cusp to form the cross ridge.

The first upper molar scarcely differs, save in size, from the last milk molar. The posterior inner cusp sends a stronger ridge upward to the posterior edge of the basal margin, and has a similar, but smaller ridge, nearly parallel with it, on the outer side.

The second upper molar has its cusps yet more approximated at the expense of the inner surface. There is a sharp and prominent basal ridge on the outer side of the valley and posterior transverse ridge, continuous with the sharp ridge running from the apex of the inner posterior cusp. The corresponding tooth of *P. macrops*, as figured by Leidy shows much resemblance to that of the same age, but differs in having a distinct basal ridge on the outer side of the first transverse ridge, and across the inner side of the valley. The third molar is more elongate, but has the same structure as in the second, wherein it differs distinctly from the corresponding tooth of *macrops*. In the present species, the sharp ridge from the inner posterior cusp is convex and directly continuous with the thin edge of the basal ridge, which is narrower. In *macrops* there is a deep incision, as in the last molar of the lower jaw, and the basal ridge is much broader.

The premolars, both above and below, are not very different from the corresponding teeth of *P. macrops* as figured by Leidy.

In the adult skulls most of the characters of the teeth that have been given are of little avail, as the teeth are so worn as to mask most of the important features, and the teeth, except the last premolars, are not much unlike those of *Dicotyles* when worn.

The canines show no grooves, or at most a very slight one, on the outer side. The permanent canines appear at the anterior and inner side of the deciduous teeth, and are broader and flatter when first erupted than are their predecessors. The permanent canines of the upper jaws which had reached nearly their full length while yet the last true molars had not yet appeared through the gums, have the hind margin thinner than the anterior, and less concave than in the milk canines. In the lower jaw of the same skull the canines had begun to be worn on the back surface near the tip. They are moderately curved, the

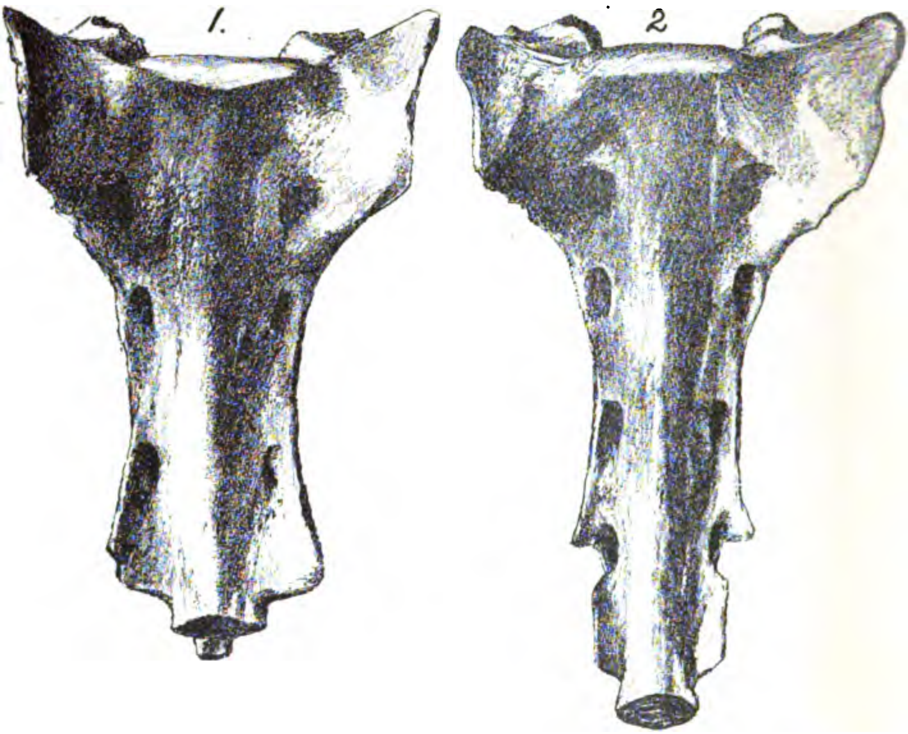
posterior surface is nearly flat transversely, the other two surfaces nearly equal, gently convex, and meeting in a moderately sharp border. In the adult skull figured of the male the upper canines have been largely worn away, the posterior border is nearly straight and have an oval cross-section at the base with the anterior border thick, the posterior thin.

| | a | b | c | d | e | f | *P. retus.* | *P. compressus.* |
|---|---|---|---|---|---|---|---|---|
| Length of first inferior molar | 15 | 12 | 10 | 13 | 13 | 11 | .. | .. |
| Width of same | 10 | 9 | 9 | 11 | 10 | 10 | .. | .. |
| Length of second inferior molar | .. | 15 | 15 | 16 | 15 | 16 | 21 | 17 |
| Width of same | .. | 11 | 10 | 13 | 12 | 11 | 15 | 11 |
| Length of third inferior molar | .. | 20 | 21 | 23 | 21 | 21 | 28 | 21 |
| Width of same | .. | 12 | 11 | 12 | 12 | 11 | 16 | 13 |
| Length of first upper molar | 14 | .. | 11 | 13 | 13 | 12 | 17 | 13 |
| Width of same | 13 | .. | 12 | 12 | 12 | 12 | 16 | 12 |
| Length of second upper molar | .. | .. | 15 | 16 | 16 | 17 | 20 | 17 |
| Width of same | .. | .. | 14 | 14 | 14 | 15 | 18 | 14 |
| Length of third upper molar | | | .. | 19 | 20 | .. | 24 | 21 |
| Width of same | | | .. | 14 | 14 | .. | 19 | 14 |
| Length of first inferior premolar | | | 9 | 7 | 10 | 9 | .. | .. |
| Width of same | | | 6 | 6 | 7 | 6 | .. | .. |
| Length of second lower premolar | | | 10 | 10 | 10 | 10 | .. | .. |
| Width of same | | | 7 | 8 | 8 | 8 | .. | .. |
| Length of third lower premolar | | | 10 | 11 | 10 | 12 | .. | .. |
| Width of same | | | 9 | 10 | 9 | 10 | .. | .. |
| Length of first upper premolar | | | 9 | * | 11 | 10 | .. | .. |
| Width of same | | | 9 | * | 10 | 9 | .. | .. |
| Length of second upper premolar | | | 10 | 10 | 10 | 11 | .. | .. |
| Width of same | | | 12 | 11 | 12 | 10 | .. | .. |
| Length of third upper premolar | | | 10 | 9 | 9 | 9 | 12 | 11 |
| Width of same | | | 11 | 13 | 13 | 11 | 15 | 11 |
| Length of lower canine, crown | | 37 | 48 | 45 | 38 | 44 | .. | .. |
| Antero-posterior diameter at base | | 10 | 15 | 14 | 11 | 12 | .. | .. |
| Width at base | | 7 | 12 | 12 | 8 | 9 | .. | .. |
| Length of upper canine | | 26 | 34 | 41 | 35 | 40 | .. | .. |
| Antero-posterior diameter at base | | 12 | 17 | 19 | 12 | 14 | .. | .. |
| Width same place | | 7 | 10 | 10 | 9 | 9 | .. | .. |

Of these measurements, those of *a* are taken from a young animal in which the first molar is the only one of the permanent teeth erupted. Those of *b* are from a skull in which the milk molars are yet persistent. Those of *c* from the adult male skull which is figured; *d* from the oldest skull, as evidenced by the teeth, in the collection, a female, which has the singular anomaly of but two upper premolars, the first never having been developed, the first premolar of the lower series being in consequence wholly unworn. The measurements of *e* and *f* are from adult females skull; the skull of *e* is the one figured.

*Undeveloped.

As will be seen, the greatest variations in the relative proportions occur in the premolars and the first molar.




*P. leptorhinus* W., ventral surface of sacrum, 1. female: 2. male. Two-thirds natural size.

**Scapula.**

The glenoid surface of the scapula is somewhat more oval than in *Dicotyles*, and the coracoid process is more prominent. The neck is more elongate, the dilatation being higher up the bone, giving the posterior border a marked concavity, where it is nearly straight in *Dicotyles*. The anterior border is strongly convex on the upper part thus making the supraspinous fossa much broader than in *Dicotyles*. The spine itself is stouter with a stouter rim, and with a stouter posterior projection above.

| | |
|---|---|
| Length of scapula | 208 mm. |
| Antero-posterior diameter of glenoid surface | 30 |
| Transverse diameter of same | 26 |
| Least width of neck | 22 |
| Greatest width distally | 97 |
| Width of supraspinous fossa | 40 |

**Humerus.**

The humerus has a more prominent great trochanter, with a stouter protuberance posteriorly for the attachment of the infra-spinatus, a

deeper notch for the biceps tendon with its posterior border more prominent, a depression below the rim, instead of a large protuberance, for the attachment of the subscapular muscle, a more prominent anterior border and greater width of the shaft just below the stronger deltoid tubercle, than in *Dicotyles*. The supratrochlear fossa is not perforated.

| | |
|---|---|
| Length of humerus | 198 mm. |
| Transverse diameter of articular surface | 38 |
| Antero-posterior diameter of shaft just below the deltoid tubercle | 33 |
| Distance between epicondyles | 40 |

**Ulna-radius.**

The fore arm is, relatively, a little longer than in *Dicotyles*. It is distinctly less arched on the distal half, the thinner superior border of the olecranon process is inflected more, making the inner surface more concave, and the concavity of the ulna border inferiorly is more nearly uniform posteriorly.

| | |
|---|---|
| Extreme length of the ulna | 212 mm. |
| Length of radius from margin of sigmoid fossa | 158 |
| Width of sigmoid fossa | 30 |
| Width of articular surface distally | 40 |
| Least width of conjoined bones | 27 |

**Carpus.**

The carpus, as well as its individual bones, is broader, the inner one of the second row is more distinctly visible from in front, there is a more distinct opening on either side of the lunar, and the scaphoid, cuneiform and trapezoid do not project as prominently on the under side.

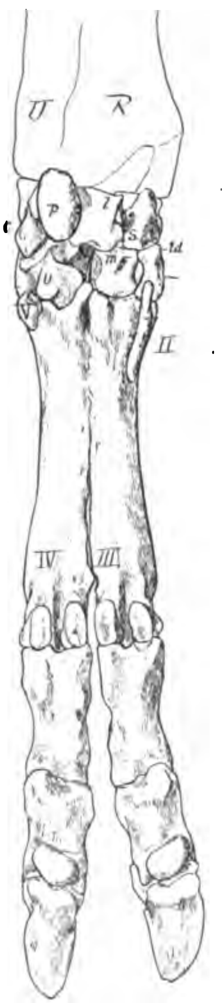
| | |
|---|---|
| Width of carpus | 36 mm. |
| Length on inner side | 27 |
| Length on outer side | 29 |

**Metacarpals.**

The middle metacarpals are relatively longer and are directed more nearly in the axis of the forearm than in *Dicotyles*. The second metacarpal is represented by a short splint about one-third of the length of the third, and which, in some specimens, shows an epiphysial end. It articulates in the same manner as the better developed bones in the peccaries. The fifth is represented by a small nodule of bone articulating with a small facet on the upper end of the fourth metacarpal. There is a small nodule articulating with a small facet on the trapezoid, which probably represents the first digit. In the drawing the splint is wrongly represented articulating with

this upper facet, and covering the one with which it articulates in reality. The third and fourth are not very strongly coossified on the upper part. Their longitudinal axis is more nearly in the same line as that of the fore arm, and the third is as long as the fourth, while in *Dicotyles* it is noticeably shorter. The conjoined bones are more expanded proximally.

Length of third metacarpal........85
Length of fourth metacarpal......86
Width of conjoined bones proximally 45



*P. leptorhinus*, palmar surface of left fore foot. *R.* radius; *U.* ulna; *s.* scaphoid; *l.* lunar; *c.* cuneiform; *p.* pisiform; *td*, trapesoid; *m.* magnum; *u.* unciform; *II-V.* second-fifth digits.

The relative proportions of the different elements in this skeleton and in that of the adult *D. torquatus* used for comparison, are as follows, the humerus in each case being 100.

| | *Platygonus.* | *Dicotyles.* |
|---|---|---|
| Humerus.................. | 100 | 100 |
| Scapula ................... | 106 | 89 |
| Ulna...................... | 106 | 96 |
| Carpus ................... | 13 | 13 |
| Middle metacarpals......... | 42 | 30 |

It is seen that the humerus is a relatively short bone in *Platygonus.*

**Tibia.**

The tibia, except that it is a little less curved outwardly on the distal part, and has a stouter cnemial crest, a more rounded external border above, and less projecting mall. olus, scarcely differs in form from that of *Dicotyles.* Its measurements are as follows.

Length ........................ 195 mm.
Diameter through condyles...... 46
Least diameter of shaft.......... 20
Antero-posterior diameter distally.- 29

**Tarsus.**

The calcaneum is stouter, and not as much compressed, the sustentaculum and the process for articulation with the fibula are more prominent.

The scaphoid is a flatter bone, its under surface has a more prominent roughening, and its proximal inferior angle is separated by a much larger interval from the calcaneum. On the cuboid, the

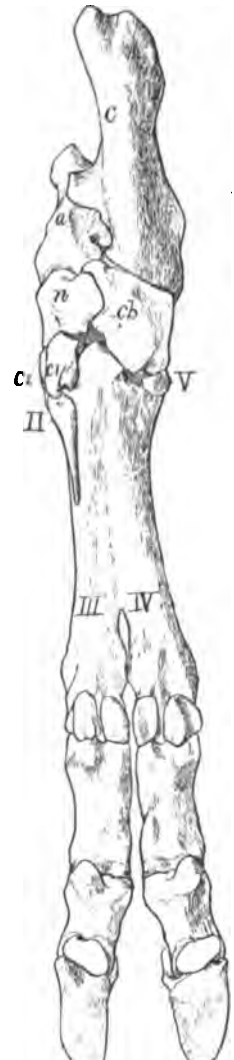
faces for the scaphoid and calcaneum are separated. The inner cuneiform is much larger than the middle cuneiform, and has projecting from its inferior border a protuberance, with a rounded, smooth articular end; its distal end projects, so as to include between it and the metacarpal the proximal end of the second metatarsal.

Length of calcaneum.............. 75 mm.
Height of same beyond articular surface...................... 25
Thickness at same place........... 15
Length of inner surfaceof astragulus. 40
Greatest width of tarsus........... 39

**Metatarsals.**

The median metatarsals resemble the metacarpals in the greater contraction of the middle portion of the conjoined bones, the ends showing a greater transverse expansion than in *Dicotyles*. They are coossified fully as well as in that genus. The distal ends of the two bones are in the same plane, whereas in *Dicotyles* the third is very distinctly shorter than the fourth. The second metatarsal is represented by a short splint which reaches a fourth or a third of the length of the conjoined metatarsals. The fifth is seen in a small nodule of bone articulating with the upper end of the fourth.

Length of fourth metatarsal exteriorly....................... 95
Length of inner side of third metatarsal....................... 96
Width of conjoined bones proximally 31
Least width of conjoined bones.... 20
Width distally, same bones........ 34




*P. leptorhinus* Willist., plantar surface of right hind foot. *c*. calcaneum; *a*. astragulus; *cb*, cuboid; *n*, navicular; *c1*, *c2*. 1st and 2nd cuneiform; *II-V*, second fifth digits

# On the Genus Dolichomyia, with the Description of a New Species from Colorado.

BY S. W. WILLISTON.

The genus *Dolichomyia* was described rather incompletely by Wiedemann,* but, so far as I can learn, has not been recognized since except by Schiner,† who described a new species of it from Chile. Even Macquart and Bigot have failed to say anything about it, and Loew‡ refers to it as a genus of doubtful relationships. The following species, therefore, makes a very interesting addition to the North American Bombyliid fauna.

**Dolichomyia gracilis, n. sp.**

Male. Eyes broadly contiguous, leaving a small, silvery white triangle below. Antennæ black, the first two joints somewhat red; first joint a little more than a half of the length of the third; second joint about as long as broad; third gently tapering from near the base. The exceedingly short face silvery white. Proboscis black, twice the length of the head and antennæ together, its terminal labella small and not at all curved; palpi black, very slender, and lying close by the proboscis, shorter than the antennæ. Mesonotum shining black, with a geminate whitish pollinose stripe in the middle; the humeri, a small spot on the post alar callosities, and another at the base of the wings yellow; pleurae whitish pollinose. Abdomen very slender and long, cylindrical, not enlarged at the extremity, composed of eight segments besides the small hypopygium; the segments dark brown in front and reddish or yellowish behind, the brown becoming greater in extent posteriorly; on the side of each posterior margin, a small, silver-white spot. Legs yellow, the distal portion of the hind tibiæ, and all the tarsi, brown, or brownish, the brown of the tarsi becoming more intense or blackish distally; hind tibiæ and tarsi with spinulæ. Wings hyaline; two or three submarginal cells present; posterior cross-vein situated near the middle of the wing, gently sinuous and nearly parallel with the costa. Knob of halteres large, dark brown or black. Length 9-11 millim.

*Aus. Zw. Ins. ii.
†Reise der Novara, Dipt. 134.
‡Diptf. Suedafrikas, 175.

Female. Front narrow above, the eyes separated by the ocellar tubercle; deep black, silvery white near the antennæ and with a white spot near the middle. Abdomen less slender.

Three specimens, Colorado, Estes Park, Prof. F. H. Snow.

This genus is related to *Systropus*, yet is very distinct. Schiner did not seem to grasp the true differences, though he insisted there were important ones. *Systropus* has, as is kown, either two or three submarginal cells. The four species known t› me all have two, so that I cannot say but that there are other differences between those with and those without the third. Loew, however, did not deem the character sufficient to separate the species. Schiner takes him to task, and asserts that he had confounded two genera, but in this I think that he was unjust. He was disposed to believe that the character was the decisive one between *Dolichomyia* and *Systropus*, but in this he was in error; the character has not even a specific importance as the specimens of the above described species conclusively show. The real differences between the two genera are as follows:

Eyes of female dichoptic in *Dolichomyia*; antennæ shorter than the head; thorax less convex above: abdomen cylindrical and not at all thickened at the extremity.

It has only been recently shown that the eyes of *Systropus* are holoptic in both sexes,* one of the very few forms among diptera in which such is the case. This is sufficient evidence that Loew had never seen *Dolichomyia* in nature, for he was the first to suspect that the eyes of the female of *Systropus* are contiguous. There are, then, but three species of *Dolichomyia* known, *D. nigra* Wied. from Columbia, *D. detecta* Schiner from Chile, and the one above described, which is closely allied to *D. nigra*.

Coquillett, in his most recent paper on the genera of *Bombyliidæ*,* rejects several genera with three submarginal cells, but, to be consistent, he should have rejected his own, based chiefly upon that very character. One may expect to find that *Rhabdopselaphus* Bigot, and *Triplasius* Loew (a North American genus which Coquillett seems to have entirely overlooked) are inconstant in this particular, and consequently untenable. But, although I have made no particular study of the genera of the *Bombyliidæ*, I do not feel so sure that Coquillett will be generally followed in his rejection of Osten Sacken's genera. Osten Sacken has made an especial study of the *Bombyliidæ*, and his appreciation of generic characters is altogether too acute to be lightly disregarded, certainly not without giving proof. It is prob-

*Osten Sacken.
†Trans. Am. Ent. Soc., xxi, 89.

ably true, as Coquillett says, that *Dipalta*, *Stonyx* and *Isopenthes* are insufficiently distinguishable from *Anthrax* by the presence of the third submarginal cell, but Coquillett wholly disregards the differences from each other, which are not at all affected by this character. That *Dipalta* is identical with *Diplocampta* Schiner seems more probable.

Coquillett seems to have been totally in error in his conception of the genus *Spogostylum*. There are three submarginal cells present in the type, as figured and described, but the third submarginal is *not* formed by the division of the outer submarginal, or, as Coquillett expresses it, by the anterior branch of the third vein having a cross-vein connecting it with the third vein. Here is another of those genera based upon the presence of a third submarginal cell, and which most probably is an inconstant character. It is of interest to note that Schiner considered* *Spogostylum* and *Argyromœba* synonymous. "Bei einem Stücke der *Argyromœba poecilophora* n. sp. erweitert sich der Aderanhang an der Basis der Cubitalgabel bis zur Radialader, es sind also, freilich nur auf einem Flügel, drei Cubitalzellen wie bei *Exoprosopa* vorhanden, was mich zu der Vermuthung führt, dass Macquart's Gattung *Spogostylum* mit der Gattung identisch sein dürfte." I have seen the same peculiarity in *Argyromœba*, and have no more faith in the character here than elsewhere.

*Reise der Novara, Dipt., 120, note.

# The Taxonomic Value of the Scales of the Lepidoptera.

BY VERNON L. KELLOGG.

In a recently published essay by Prof. John Henry Comstock (of Cornell and Leland Stanford, Jr. universities), entitled "Evolution and Taxonomy,"* is shown an appreciative recognition of the demands which the theory of descent makes upon its believers. Professor Comstock believes that the systematists of today are not making as much use of the theory of descent in taxonomic work as they might. "We are still busy describing species as if they were immutable entities," he says, "and in our descriptions we give little thought to the causes that have determined the forms of organisms. It is true that considerable has been done in the direction of working out the phylogeny of the larger groups, as branches and classes, and to a less extent of orders, but rarely is any effort made to determine the phylogeny of the smaller groups."

Continuing, Professor Comstock writes as follows: "Here I believe lies the work of the systematist of the future. The description of a new species, genus, family or order, will be considered incomplete until its phylogeny has been determined so far as is possible with the data at hand. We are to care less for the mere discovery of new forms, and more for an understanding of the processes by which new forms have arisen. The object of taxonomy will not be a mere grouping of forms according to similarity of structure, but the systematist will have constantly before him the question: What do these variations of form mean? With this change in the objects of taxonomic work, there will come a change in its methods.".

The method of work which Professor Comstock believes should be followed by the systematic student is stated by him as follows:

"As the structure of a highly organized animal or plant is too complicated to be understood in detail at once, it is suggested that the student begin with the study of a single organ possessed by the members of the group to be classified, and that his study take the

*Comstock, John Henry, Evolution and Taxonomy: an essay on the application of the theory of natural selection in the classification of animals and plants, illustrated by a study of the evolution of the wings of insects, and by a contribution to the classification of the Lepidoptera. pp. 37-113, with 33 figures and 3 plates in the Wilder Quarter-Century Book, 1893, Ithaca, N. Y.

following course: First, the variations in form of this organ should be observed, including palæontological evidence if possible; then its function or functions should be determined. With this knowledge endeavor to determine what was the primitive form of the organ and the various ways in which this primitive form has been modified, keeping in mind the relation of change in form of the organ to its function. In other words to read the action of natural selection upon the group of organisms as it is recorded in a single organ. The data thus obtained will aid in making a *provisional* classification of the group.

"When this stage has been reached another organ should be selected and its history worked out in a similar way.

"The results of the two investigations should then be compared; and where they differ there is indicated the need of renewed study. For if rightly understood the different records of the action of natural selection will not contradict each other. The investigation should be continued by the study of other organs and a correlating of the results obtained until a consistent history of the group has been worked out."

In the study of the scales of the Lepidoptera, a study suggested to me by Professor Comstock, I have endeavored to follow the lines indicated in the above-described method, believing that systematic workers who accept the theory of descent (and practically there are no others) must, that their belief and their works shall be consistent, move along the general lines pointed out by Professor Comstock.

## II.

The great diversity of shape and size among the scales of moths and butterflies is a matter of common remark among entomologists. So nearly infinite, seemingly, are these variations that it is with hesitancy that one undertakes to find order in this chaos. But immensely greater diversity of structure has been found to resolve itself into approximate simplicity, and the "dust of the butterfly" is, after all, a more or less reasonable dust, and exhibits a tolerably rational behavior in its developmental caprices.

This extreme diversity of character of the scales, and the fact that the scales from one wing may show a great variation in shape and size has deterred systematists from paying them much attention, although this same variety of design, together with the beauty of color of the scales, and their interesting regularity of marking (striation) have made them favorite objects with the microscopists. The suggestion of a writer that the forms of scales might be used for specific characters is said by Westwood to have no weight, as

"Lyonnet has filled several quarto plates with representations of these scales varying to almost every form taken from the wing and body of the Goat Moth."

The scales, most commonly, are more or less oval in outline, and insecurely attached to the membrane of the wing by a short, obtusely-pointed pedicel arising from the narrower end of the oval. The broader end has a margin entire, or showing dentations of varying depth and number. These dentations may be so deep, and the accompanying teeth so long and slender, that the term "fingered" will better express the appearance. In size the scales vary in length from .07 mm., *Micropteryx*, to .8 mm., *Castnia* sp., if we consider only scales of such specialization as no longer preferably to be termed scale-hairs, and exclude the scales on the outer margin of the wing, which are always unusually long and slender. In width the scales vary from a hair-like condition to .4 mm. as in *Castnia* sp. The relation of length to breadth varies much; on *Castnia* sp. some scales are just as broad as long, and some even broader than long. The well specialized scales are flat (except in the case of androconia) and are striated longitudinally, i. e. from base to opposite margin, these striæ being very regular as regards the distance between contiguous lines. The distances between the striæ vary from .0007mm. as in *Morpho* sp. to .004 mm. as in *Callidryas eubule*.

Figure 1, a group of differing scales, displays these salient points of outline.

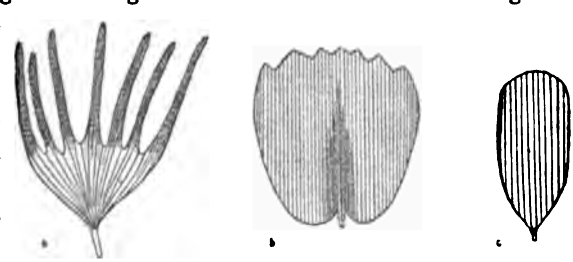


Fig. 1.
a, scale of Tolype velleda: b, scale of Castnia sp.; c, scale of Micropteryx aruncella.

The scales cover (in most Lepidoptera) the wings on both upper and lower sides, and present varying conditions of arrangement on the wing-membranes. In any one of the more specialized butterflies, a *Morpho*, for example, this arrangement is remarkably uniform. The scales are inserted, with their pedicels directed toward the base of the wing in sub-parallel rows running transversely across the wing, i. e. from costal to inner margin, and the scales in each row are inserted at approximately equal distances apart. Each row is practically composed of two tiers of scales, an under and an upper tier: the insertion cups of one tier are very slightly but

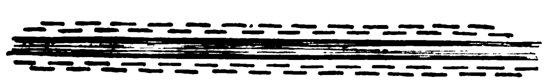


Fig. 2.
Diagram of cross-section of portion of a wing, showing arrangement of scales.

perceptibly advanced beyond those of the other tier. The scales of the upper tier alternate with those of the under tier, and each upper scale overlaps laterally two under scales. In *Morpho* the upper scales overlapped the under scales but little; in *Callidryas eubule* two adjacent upper scales covered fully two-thirds of the scale lying beneath and between them; often the margins of the two adjacent upper scales almost met along the median line of the under scale. In a *Lycænid* the upper scales overlapped about one-fourth the scale's width on each margin; in *Papilio troilus* the overlapping was about the same; in another *Papilio* the under scales were almost entirely covered.

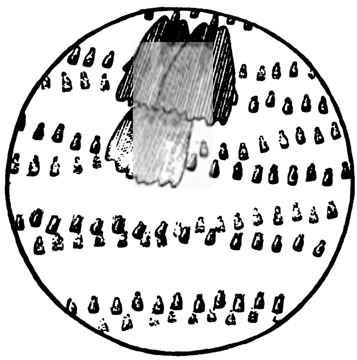


Fig. 3.
Part of wing (magnified) of Grapta interragationis, show rows of insertion cups on under and upper surfaces.

This arrangement of the scales is more easily understood by reference to figures 2, 3 and 4. In addition to this lateral overlapping, the distance between the points of insertion of the scales of one row and the points of insertion of the scales of the row just in front or just behind it is less than the length of the scales, so that there is an overlapping of the tips of the scales of one row over the base of the scales of the row in front (see figs. 2, 3 and 4). By this double overlapping of the scales there is formed a complete covering or sheet of scales over the upper and under surfaces of the wings, and often times almost a double sheath or covering. The rows of scales on the under surface of the wing exhibit no uniformity of relation with those of the upper surface, i. e., a row on the under surface does not have directly above it on the upper surface a row in which the scales are inserted at points corresponding exactly in position with the insertion points of the scales of the under row; nor is there a regular alternation of rows. In fact, rows on the lower side of the wing are but rarely approximately parallel with rows on the upper side. Figure 3 represents a portion of the fore wing of *Grapta interrogationis* denuded of scales but showing the rows of insertion cups of both surfaces, the cups of the under side showing through.

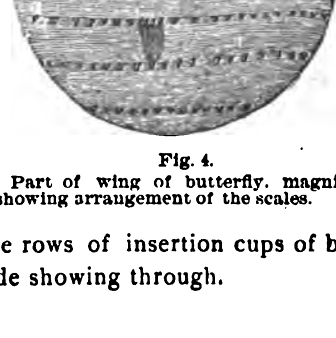


Fig. 4.
Part of wing of butterfly, magnified, showing arrangement of the scales.

This very regular arrangement of the scales on the wings is not, however, found in all Lepidoptera. Indeed, only among the butterflies and a few families of moths can a condition even approximating the regularity above described be found. The significance of the arrangement of the scales, and the taxonomic value of different conditions of scale arrangement are discussed later.

This close placing and overlapping of the scales bring it about that the number of scales on a wing is truly prodigious. In *Morpho* sp., for example, the distance apart of the lines of insertion pits on a bit of the upper wing surface taken from the middle of the forewing is .151 mm.; the distance apart of the pits in a line is .043 mm. (on the under surface the pits were .05 mm. apart); so that in a space 25 mm. by 25 mm., (1 sq. in. *circa*) there would be 165 lines of scales with 600 scales in each line, or 99,000 scales to each square inch of wing surface. As the upper and under surfaces of the fore and hindwings combined equal about 15 square inches the total number of scales on the wings of *Morpho* may be roughly approximated at 1,500,000.

The scales are attached to the wings by means of their short pedicels fitting into minute pouches or cups on the surface of the wing membrane. These minute pockets or cups are in general subconical in shape, and vary somewhat in length (or depth) in different species. In *Micropteryx unimaculella* they average about .008 mm. in length; in *Pieris protodice* .013 mm. in length; in *Morpho* sp. .016 mm.; in *Castnia* sp. (about the size of *Vanessa antiopa*) .026 mm.; these being the largest cups I have observed. In *Erebus strix*, one of the largest moths, if not the largest one, the cups average .015 mm. in length.

The cups sink but slightly, in the more specialized cases of scale-covering, into the wing-membrane, the outer open end being, of course, at the surface of the membrane, and the inner closed end or bottom of the pocket being only slightly below the surface, so that the scale does not stand out from the wing-surface at a considerable angle but lies closely against it. In fact, rather than being sunken into the membrane, the cups rise above the surface as shown in figure 5, a cross-section of part of the forewing of *Parnassius smintheus*. Thus the cups are more truly little pockets on the surface of the wing, than pits or cavities in it.

Fig. 5.
Diagram of a cross-section of a part of the wing of Parnassius smintheus, showing insertion cups.

The cups vary slightly in shape, also, from simple, obtusely-pointed, inverted cones (the apex being the bottom of the cavity) as shown in *Eudamus tityrus*, to goblet-shaped cavities, bowl outwards, as in *Pieris protodice*. In *Erebus strix* the cup is contracted at the

opening and at the base (the bottom of the scale cup) there is an expansion.

The manner in which these insertion cups are developed in the forming wing is described by Landois* as follows:

"Jede Schuppe wird durch eine besondere Vorrichtung auf dem Flügel befestigt, welche wir die Schuppenhalter nennen wollen. An dem vollkommenen Insectenflügel besteht jeder einzelne Schuppenhalter aus einem kleinen Röhrchen, welches mit seiner Basis in der Epidermis des Flügels innigst verwachsen ist. Es ist an der einen Seite stets von oben nach unten geschlitzt, und zwar so, dass dieser Längsspalt am obern Ende etwas auseinander klafft. Der Schuppenhalter erhält durch diese Einrichtung eine elastisch federnde Kraft, womit er den nach unten sich verjüngenden konischen Stiel der Schuppe festzuhalten im Stande ist. Die Bildung und der Bau dieser Schuppenhalter lässt sich vorzüglich bei unserm Eckfalter studiren. Es ist auffallend, dass die bisherigen Forscher diese Gebilde nicht erwähnen, indem sie sich mit der Angabe begnügen, 'dass die Schuppen in einem Loche der Epidermis festsitzen.' Der eigentliche Sachverhalt ist jedoch folgender. Sobald der Flügelschuppenschlauch durch die Hypodermis des Flügels hindurchtritt, drängt derselbe eine Hypodermiszelle etwas zur Seite. Dadurch erhält die betreffende Zelle eine halbmondförmig eingedrückte Gestalt. Die typische Form behält die Zelle auch in ihrer weitern Entwicklung. Die beiden Ränder dieser Zelle rücken später etwas weiter um den Schuppenstiel, verwachsen aber oben nie mit einander, sondern bleiben als Spalt des Schuppenhalters bestehen. Das untere Ende wächst später zusammen, und zwar veranlasst durch den Druck, den die nebenliegenden Hypodermiszellen auf diese Zellen ausüben. In spätern Stadien chitinisirt die Zelle, und wir haben den oben beschriebenen Schuppenhalter vor uns."

The pedicels of the scales are of slightly varying shapes and of different lengths corresponding with the pockets into which they fit. Those which enter insertion cups which are expanded at the base, or at some point between the base and the mouth, present at the tip or between the tip and the point of merging into the blade of the scale, respectively, a slight expansion, so that they are pretty firmly held in the cup by a sort of ball and socket attachment. The scales are held in position by the elasticity of the cups which closely clasp the pedicels. After death of the moth or butterfly this elasticity is largely lost, by desiccation of the wing membrane, and the pedicels are more easily brushed from the wing than when the insect is alive.

*Landois, H., Beitraege zur Entwickelungsgeschichte der Schmetterlingsfluegel in der Raupe und Puppe. Zeitschr. f. wiss. Zool., vol. 21, 1871.

The pedicel is usually plainly distinguished from the blade of the scale, but in some cases there is a gradual tapering of the blade towards the base, a gradual fading out of the striæ and it is difficult to say where the pedicel begins or the blade ends (see fig. 6.).

Fig. 6.
a. base of scale of Gloveria arizonensis; b. base of scale of Morpho sp.

The histology of the lepidopterous scale has been given considerable attention, not only by microscopists attracted by the variety of design, the symmetry of outline and fineness of marking, but also by histologists seeking to reveal the intimate structure of these characteristic features of the Lepidoptera.

The scales are flattened sacs, composed of two membranes, enclosing sometimes only air, sometimes pigment granules attached to the inner face of one of the membranes, and sometimes (as observed in cabinet specimens) the dry remains of what may have been during life an internal pulp.* The striæ are confined to the outer membrane (that farthest from the wing membrane) and are probably folds in this outer membrane (see fig. 9). The striæ are plainly elevated above the inter-strial space. All scales, excepting some androconia, possess these longitudinal striæ, which traverse the scale from base to outer margin and are very sharp, and separated from one another by equal distances. The striæ sometimes curve in at the lower angles of the blade, converging toward the origin of the pedicel; in other cases they fade out at these angles. In scales of *Danais archippus* from 33 to 46 striæ, averaging .002 mm. apart, are present on each scale. There would thus be 12,500 of these striæ to the inch. On transparent scales from *Morpho* sp. the striæ were .0015 mm. to .002 mm. apart, on opaque (pigment-bearing) scales from the same specimen the striæ were from .0007 mm. to .00072 mm. apart or at the rate of about 35,000 to the inch.

Fig. 7.
Scale of Hepialus mcglashani, showing primary and secondary striation.

While these striæ are in most cases uniform in appearance on a single scale, in a few instances there are a few specially heavy and pronounced striæ, each one terminating at the outer margin in a short point or tooth. These striæ are separated by equal distances, while between them are ordinary fine longitudinal striæ. There is thus produced an effect which may be expressed by attributing to the scale a primary and a secondary

*Minot and Burgess in their description of the anatomy of *Aletia* (4th Rept. U. S. Ent. Com., 1885, Washington) declare that in all of the scales examined by them there was always an internal pulp which contained coloring matters.

Fig. 8.
Scale of Lycomorpha constans, showing cross striæ.

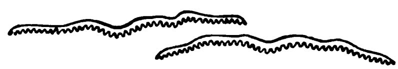


Fig. 9.
Cross-section of scales of Parnassius smintheus. (The striæ are on the surface not facing the wing-membrane.)

striation. This condition obtains in the scale of *Hepialus* (see fig. 7). Burmeister (*loc. cit.*) has observed this difference of striæ in a Pyralid, *Nomophila.*

In addition to the longitudinal striæ some scales have cross-striæ, but as far as I have observed these cross-striæ do not intersect the longitudinal lines, but merely extend transversely between them. Scales from *Callidryas eubule* plainly show these transverse striæ, which average about .0009 mm. apart. In scales of *Lycomorpha constans* (see fig. 8) similar cross-striæ are about the same distance apart as the longitudinal striæ, namely .0014 mm.

The scales are not evenly flattened, but the middle portion of the scale-blade (see fig. 9) is thicker than the lateral portions. The scale is also irregularly corrugated, as shown in figure 9. In accounts of the structure of the scales by various writers some errors of observation are apparent. Deschamps* says that the scales are often composed of three superposed membranes or lamellæ. "Toutes les écailles qui recouvrent les ailes des lepidoptères me paraissent formées de deux et le plus souvent de trois membranes ou lamelles. Sur la membrane supérieure se trouvent les granulations dont se compose la matière colorée de l'écaille. * * * Lorsque se présentent des striés, c'est toujours sur la deuxième lamelle qu'elles sont posées." Deschamps was limited to studying broken scales in which at best the making out of the structure, in later days easily determinable by sectioning, would be a difficult matter.

A deal of rather unprofitable discussion among microscopists regarding certain "beads" or "villi" alleged to be visible on the scales of butterflies has been carried on. A paper by S. S. McIntire† on the external histology of scales sums up the writer's belief regarding these "beads" as follows: "That the beaded appearances seen in scales are due to the following causes, either singly or collectively: (a), corrugations, taking the form of hemispherical embossings; (b), pigments; (c), shadows of projections or folds in the membrane either within or beyond the focus of the object-glass."

Probably the best general account of scale-structure is that of

*Deschamps, Bernard, Recherches microscopiques sur l'organization des ailes des Lepidopteres. Ann. d. Sci. Nate. 2me. serie, III, 1835. Paris.

†McIntire, S. S., Notes on the minute structure of certain insects. Monthly Mic Journal, vol. 5, 1871, London.

Burmeister* based on a careful examination of the scales of *Castnia*. He says that the two outer membranes of the scale do not enclose a third lamina, but claims that the scales are empty, "contenant seulement de l'air dans l'intérieur * * * Dans les colorées [pigmented] ce vide contient une matière fluide au commencement de la formation de l'écaille, qui dessèche peu à peu par l'influence de l'air atmosphérique et laisse un dépôt sur la surface intérieure des deux lames de l'écaille; enfin le fluide remplacé par l'air atmosphérique qui est entré peu à peu par la resorption de la membrane, encore molle, immédiatement après la formation de l'écaille." Burmeister believes that the striated appearance of the scales is due to the presence of filaments which project into the interior of the scale from the inner side of the outer membrane: "Il n'est pas douteux que les striés bien visibles des écailles soient des fillets élevés au côté interne de la lame supérieure, se prononçant au côté externe seulement comme striés finement imprimés." My observations of sectioned scales show this not to be the case. Minot and Burgess† also call attention to this declaration of Burmeister as not sustained by their observations.

## III.

An inspection of the scales of the Lepidoptera will reveal, as already remarked, a considerable variation in size and outline, but reflection will convince the observer that the extremes of this variation in outline are reached when on one hand there is taken a long, slender, hair-like scale such as those characteristic of the hindwings of *Megalopyge crispata*, and on the other hand there is taken the stiff, flat, symmetrical scale plainly divided into short, sub-cylindrical pedicel and broad, striated blade characteristic of the forewing of *Danais archippus*. There are forms long and slender but widening at the tip and having two or more points or teeth, as in *Actias luna;* forms with short, wide blade with its outer margin entire as in *Micropteryx*, or presenting several short teeth or points, as in *Castnia* sp., or with several long, tapering fingers as in *Tolype velleda*. Nor is it necessary to search among different genera or species to obtain a large series of varying outlines: they may often be found on one wing of a single moth, though there is a suggestive uniformity of essential character about such a series of forms. Such a series of gradatory forms from the forewing of *Megalopyge crispata* is shown in figure 10.

*Burmeister, H., "Examen special des Ecailles." pp. 21-28 in Description Physique de la République Argentine, 5me. tome (Lepidopteres), 1re. partie, 1878, Buenos-Ayres.

†Minot and Burgess, loc. cit.


Fig. 10.
Scales taken from single forewing of *Megalopyge crispata*.

Coupled with this variation in the form of the scales it is to be noted that the more slender and hair-like forms are more or less assurgent, and are not appressed to the wing membrane, while the flattened forms with pedicel and blade lie closely against the wing-surface. The direction of the long axis of the insertion cup varies correspondingly; those cups from which flat scales arise lying more nearly parallel with the wing membrane, while those from which hair-like scales arise are directed more toward the interior of the wing substance.

Variations in the mode of arrangement of the scales on the wings may be comprised within two extremes: a condition of arrangement whereby the scales are scattered over the surface of the membrane, their insertions at approximately equal distances apart, but with little or no suggestion of any rows of scales, as shown by *Micropteryx*: and a condition as that described and figured on p. 48 (fig 3), in which the scales are uniformly arranged in rows, each of two tiers, and running subparallel with adjacent rows. It is to be noted that an arrangement of the scales in rows and tiers is only associated with broad, flat scales; the long, slender, hair-like forms of scales are never arranged in rows. But the converse of this, that all flat, broad, scales are arranged in regular rows and tiers is not true. One may find flat scales covering a wing, but showing little arrangement into sub-parallel rows. This may be well seen in *Micropteryx*.

## IV.

The functions fulfilled by the scales, once understood, must give a clue to the rationale of the tendency of the specialization of the

scales. Primarily, I believe, the scales serve to protect and to strengthen the wing-membranes. Although the membrane of the wing is chitinized, it is still thin and delicate. Excepting the discal vein, which, indeed, may be wanting, there are rarely cross-veins in the Lepidopterous wing. There are thus left open spaces of considerable area between the sub-parallel longitudinal veins. In the Neuroptera, Odonata, etc., these intervening spaces are strengthened by many cross-veins. In the Lepidoptera the transverse rows of scales, or rather the complete sheath of scales, may do much to make good the absence of cross-veins. The veins of the wings grow weaker and more widely separated as they approach the outer margin of the wing, yet the wing-membrane in the broad, limbal area of the wing has to endure a greater strain in flight than the membrane of the discal and basal area of the wing, where the veins are large and close together. There would thus exist a need, more or less impelling, as the flight-use of the wing varied, for a strengthening of the membrane of the wing. This need of strengthening would vary on the different parts of the wing, the limbal area needing it more than other areas. If the scales could subserve this function of strengthening the membrane it is apparent that the flat scale with short, stiff pedicel and broad blade, lying closely against the membrane would be much better fitted to fulfil this function than would the slender, flexible, hair-like form rising weakly from the wing-membrane. The flattened scale would have additional strength, too, from its corrugated condition (shown in fig. 9), as the corrugations would help to prevent bending of the scales; the longitudinal striations also better enable the scale to resist a force tending to bend it at right angles to its long axis which, from the manner of the scale's insertion on the wing (viz.: with its pedicel directed toward the base of the wing) would be the case during flight. If, also, there were any variance in the scale-development on the wing, that state of development best adapted for strengthening the membrane found anywhere on the wing should be found on the limbal area of the wing.

That this condition above described as the one among all the forms and kinds of scales observable among Lepidoptera best adapted for the function of adding strength to the membrane does actually obtain on the limbal area an inspection of the wings of Lepidoptera soon demonstrates, while the basal and anal areas present those of all the scales of the wing most widely departing from the type of flat, blade-like form.

I consider, therefore, the flattened, symmetrical scale, with short, stiff pedicel and broadly expanded, irregularly corrugated and striated blade the more specialized form of scale; while the slender, flexible, hair-like form is the more generalized condition.

It is evident also that a regular arrangement of the scales in transverse rows, with the scales of one row overlapping those of the row in front and with the scales in each row overlapping by their lateral margins, as described and illustrated on pages 47 and 48, figures 2, 3 and 4, producing an evenly disposed covering or sheath of scales over the membrane, would better subserve the function of strengthening the wing-membrane than would a condition of arrangement whereby the scales were irregularly scattered over the wing-surface. Even though the scales might be numerous enough in this condition to form a fairly complete covering over the membrane, its strength would be uneven, and its adaptation for its function inferior to the more regular arrangement. An inspection of any wing shows that the nearest approach to a regular arrangement of the scales in rows and tiers to be met with anywhere on the wing is to be found on the limbal area, where the necessity for a strengthening of the membrane is most urgent.

A regular and uniform scale-arrangement may therefore be considered to be a more highly specialized condition than an irregular arrangement of the scales.

Confirmation of what the function and specialized form of the scales are is offered by a further examination of the wings, while having in mind the use of the wings in flight. In addition to the correlation just cited between the specialization of scales and scale-arrangement of the limbal area of the wing and that area's special need in flight, it is apparent that the costal area of the wing plays a more important part in flight than the anal area; a comparison of the scale-covering shows a higher specialization of scale-form and arrangement in the costal than in the anal area. Again, as the tendency in Lepidoptera is towards a cephalization of flight, the forewings are much more important in flight than the hindwings. A comparison of the covering of the fore and hindwings usually (uniformly, where considerable cephalization of flight has been attained) shows that the scale-forms and arrangement of the forewings much more nearly approach those specialized conditions previously described than do the scale-forms and arrangement of the hindwings. And, finally, offering a general character of some taxonomic importance, the scale-specialization is higher in moths (for the time being I exclude butterflies from consideration, as explained later) of highly-specialized flight-function (indicated by cephalization of flight) than in moths of more generalized flight-function, as, for example, the Sphingidæ compared with the Saturniidæ. But the hind wings of moths where an extreme cephalization of flight has been arrived at, show a less specialization of the scale-covering than is shown by the hind wings

of moths whose flight-function is not so excessively cephalized. Which, indeed, is to be expected, because of the lesser importance of the hind wings in cases of extreme cephalization of flight.

This is well shown within the limits of a single family in the case of *Calyasymbolas myops*, a Sphingid with the hind wings large in comparison with the hind wings of *Chærocampa*, *Philampelus*, *Ellema* and others showing extreme cephalization of flight. In *Calyasymbolas* the disk of the hind wing is uniformly covered with flat scales, only the basal third of the wing showing long, weak scale-hairs. In *Philampelus achemon* only the marginal brown edging is composed of specialized scales, without the presence of scale-hairs, while all the discal and basal portion of the wing is covered with long, rather thickened scale-hairs, in addition to flat scales. *Chærocampa tersa* shows a similar condition, as also does *Ellema bombycoides*.

The fact that a heavy flyer shows a less specialized scale-covering than a swift flyer is also illustrated among the Sphingidæ. *Triptogon modesta*, a slow, heavy-bodied moth compared with *Philampelus*, has its forewings covered with long, thickened, two- to three-pointed, rather flattened scale-hairs thickly inserted, but rather assurgent, and not closely appressed to the wing-surface. The hindwings bear elongate, single-pointed scale-hairs, and also some scales like those of the forewing; altogether a much more generalized condition of scale development than that of *Philampelus*, whose forewings are uniformly covered with broad three- to seven-pointed flat scales, becoming a little longer toward the base of the wing.

These generalizations are based on an examination and comparison of a large number of forms, and specific examples will be adduced in different groups of moths.

These conclusions as to what is the most highly specializ d condition of scale and arrangement are further confirmed by the fact that these conditions obtain in those forms of Lepidoptera which are considered by entomologists to be the most specialized forms of the order; a conclusion reached without reference to the scales. The Nymphalidæ show as highly specialized a scale-covering as is to be found among the Lepidoptera. It is also true that among those groups of moths considered by entomologists to be the most generalized, as the *Megalopygidæ*, the scale covering does not attain nearly as specialized a state as among the groups of more specialized Lepidoptera.

The most generalized form of the scale apparent on the wings of Lepidoptera is, it is evident from the foregoing, that long, slender, flexible form, between which and the most specialized form, the flat scale, a whole series of gradations, each succeeding form better adapted for its function, is to be found.

The transition from simple hair to broad, flat scale is easily observed, a long and interesting series of gradatory forms being obtainable sometimes from a single moth. The transition most commonly occurs by (a), the slight thickening and widening of the distal portion of a hair; (b), the dividing, or apparent splitting of the thickened distal portion into two, three or more branches or fingers, lying in one plane; (c), the gradual shortening of the proximal or basal portion of the scale-hair, accompanied by a widening and "filling in" between the bases of the fingers. This palmation may extend almost or quite to the tips of the fingers, or the fingers may remain as long as the rest of the scale, or longer. There is thus produced a flat scale with more or less shortened pedicel (the proximal end of the hair) and with its opposite (outer) margin entire or two- to several-pointed, the points being of greater or less length. The longitudinal striæ are apparent with the first widening of the hair.

This transition is well shown on the wing of *Megalopyge*, a genus presenting probably the most generalized condition of scale covering yet found by me in the Lepidoptera (see fig. 10, p. 54).

Variations from this method of transition occur, as shown in a discussion of the lines of specialization of the scales (*postea*) but all begin from a long, slender, hair-like form.

In searching for the beginnings of the Lepidopterous scale, an inspection of certain groups of insects whose phylogenetic relations with the Lepidoptera are an interesting entomological problem, presents some most interesting and suggestive conditions. An inspection of the wings of the Trichoptera reveals a wing-covering of the following character: a uniform covering of very small, slightly curving, pointed hairs, firmly attached to the wing-membrane and not inserted in a socket or cup; and also a varying covering of long, usually striated, more or less flattened scale-hairs distinctly set in insertion cups, and showing a more or less distinct, unstriated pedicel, and not firmly attached to the wing (see fig. 1, Plate IX). The fine fixed hairs vary in length somewhat in different species, but are always much shorter and more numerous than the scale-hairs. The scale-hairs usually plainly indicate their scale condition, being often flattened, regularly striated, and possessing a distinct pedicel. A *Setodes* sp. presents the following characters in the wing-clothing: the fine, fixed hairs are about .008 mm. in length, and are situated about .007 mm. apart. The scale-hairs vary from hair-like structures to flattened scales, about .07 mm. to .10 mm. in length and about .008 mm. in width, bearing uniform longitudinal striæ .0016 mm. apart. The pedicel is distinct from the scale-blade, and presents a slight expansion near its

tip. The insertion cups are practically identical with those found among Lepidoptera, goblet-like in form. *Mystacides punctata* has, in addition to the usual scale-hairs, about .1 mm. long and .005 mm. wide, opaque, striated and slightly curving, the limbal area of the forewing sparsely dotted over with certain conspicuous, balloon-shaped scales (see figs. 5, 6 and 7, Plate IX). They are white, with a granular content, finely striated, and average about .0736 mm. in length and .0086 mm. in width at the widest part. They are not flat, but flattened bulbous, and strongly suggest an identity with the androconia, or scent scales of the Lepidoptera.

The scale-hairs of the Trichoptera are more abundant on the limbal than on the basal area of the wing, and exhibit no arrangement in regular rows or tiers. In some species they are numerous enough to compose a rather complete hairy covering or sheath over the wing.

The scale-hairs in many forms are little or not at all flattened, but are sub-cylindrical, tapering to a point. There is in these scale-hairs but slight distinction between pedicel and body of the scale-hair, and the greatest width or diameter of the scale-hair is at its base. A cross-section of such a scale-hair showed elevated ridges or striæ over the whole surface.

Such unflattened scale-hairs are found also among the Mecoptera together with the covering of fine, fixed hairs. In *Panorpa* sp. the fore wing is uniformly covered with fine, fixed hairs, little if any longer on the limb than on the basal area of the wing and no more abundant. There is also a sprinkling of much longer tapering, sub-cylindrical hairs, thickest at the base and without distinctly set off pedicel (see fig. 2, Plate IX). These hairs are inserted in a sort of socket, and rise nearly at right angles with the wing. These inserted hairs are not present on the basal one-fourth of the wing. There are less than one-tenth as many of these inserted hairs as of the fine, fixed hairs. The inserted hairs are situated about .065 mm. apart, and the fine hairs about .013 mm. apart. The inserted hairs are not found near the veins, but only in the central portions of the cells of the wing, there being a considerable space on either side of a vein which is free of inserted hairs. On the veins themselves, however, there are stiff inserted hairs in single rows, the hairs in the row at intervals of .053 mm. The inserted hairs are from .06 mm. to .12 mm. long, and show faint indications of striation; the fine hairs are about .02 mm. long. On the hind wing the inserted hairs do not appear on the basal third of the wing and in very small number on the middle third; they are not common except on the extreme limb of the wing.

It is of interest to note, as bearing upon the strengthening function

of the scales, that in the Mecoptera the cross-veins, rather numerous, show indications of fading out. In *Panorpa* many of the cross-veins are very faint in their median portion, and are plainly tending toward obliteration. In the Trichoptera, with wing-covering more specialized than that of *Panorpa,* the cross-veins are comparatively few, and in the Lepidoptera, of most specialized wing-covering, except for the discal vein cross-veins are rarely present.

Turning now to the Lepidoptera, an interesting condition of the wing-clothing of certain forms is presented; especially interesting in the light of our examination of the wings of the Trichoptera and Panorpidæ. A careful inspection of the wing-membranes of *Micropteryx* reveals on them, in addition to the numerous specialized scales a covering of very fine hairs differing radically from the scales in size, arrangement and mode of attachment to the membrane, and agreeing essentially with the fixed hairs of the Trichoptera (see fig. 4, Plate IX). These minute hairs are present in all the species of *Micropteryx* I have examined, viz.: *unimaculella, anderschella, mansuetella, chrysolepidella, clathrata, thunbergella, sparmanella, fastuosella, aruncella, seppella, fastuosella,* and *semipurpurella.* Further a similar condition of wing-covering occurs in the genus *Hepialus* (see fig. 3, Plate IX), of which I have examined the following species: *sylvinus, gracilis, humuli, argentata, haydenii, hecta, purpurascens, argenteomaculatus, mcglashani, behrensii* and its variety *montanus.* These two genera are the only genera in their respective families, the Micropterygidæ and the Hepialidæ, and these two families constitute the suborder Jugatæ of Professor Comstock. All the rest of the known families of Lepidoptera are comprised in the suborder Frenatæ of Comstock. I have yet to discover these hairs in any one of the Frenatæ, though I have examined a large number of forms distributed widely over the group. I am convinced that the presence of this clothing on the wing-membranes of the Jugatæ is a subordinal character.*

This fine hair clothing in the Jugatæ may be specifically described as follows: in *Micropteryx unimaculella* (see fig. 4, Plate IX), the fore

*The new provisional classification of the Lepidoptera by Professor Comstock (loc. cit.) based on characters drawn from the wing structure, presents as its most radical departure from earlier arrangements, the erection within the order of two suborders. One of these groups, the Jugatæ, is thus defined: "This suborder includes those moths in which the two wings of each side are united by a membranous lobe, the jugum, borne at the base of the inner margin of the fore-wings, and in which the anal area of the hindwings is reduced while the radial is not. The most available recognition character is the similarity in venation of the two pairs of wings; radius being five-branched in the hindwings as well as in the forewings." This suborder comprises but two families, the Micropterygidæ and the Hepialidæ.

The suborder Frenatae is characterized as follows: "This suborder includes those moths and butterflies in which the two wings of each side are united by a frenulum, borne at the base of the costal margin of the hind wings, or by a substitute for a frenulum, a large humeral area of the hind wings; and in which radius of the hindwing is reduced to an unbranched condition, while in the more generalized forms the anal area is not reduced. The most available recognition character is the dissimilarity in venation of, the two pairs of wings, due to the unbranched condition of radius of the hindwings while this vein in the forewings separates into several branches." The Frenatæ includes all the families of Lepidoptera except the Micropterygidæ and the Hepialidæ.

and hind wings on their upper and lower sides are sparsely covered with fine, curving, pointed, short hairs not inserted in sockets or "insertion cups," as are the scales, and not easily rubbed off. These hairs average .005 mm. in length, and are distant from each other at their bases a length approximately equal to the length of the hairs. The scales of *unimaculella* average from .1 to .15 mm. in length. In *Hepialus sylvinus* (see fig. 3, Plate IX), the wings are similarly covered with fine hairs, averaging from .02 to .03 mm. in length. The scales of *sylvinus* are from .2 to .3 mm. long, or about ten times the length of the fine hairs.

Beyond the availability of the presence of the fine hairs in the Jugatæ and their absence in the Frenatæ as a recognition character* the phylogenetic significance of this character seems to me of interest, and especially so in the light of Professor Comstock's recognition of two main divisions of the Lepidoptera. The Jugatæ, according to Professor Comstock, are the more generalized group of the two sub-orders. The venation indicates this strongly; *Micropteryx* possesses the most generalized mouthparts to be found among Lepidoptera; and, lastly the mode of tying the wings together is the same as obtains in many of the Trichoptera, a group of insects offering many indications of affinity with the Lepidoptera. In addition to these indications, or, indeed, demonstrations, of the generalized condition of the group Jugatæ, the correspondence of the essential features of the wing-clothing of the Jugatæ and the Trichoptera suggests anew the generalized condition of the Jugatæ. The figures in Plate IX (see figs. 1, 2, 3 and 4) of the clothing of the wings of *Micropteryx*, *Hepialus*, *Neuronia* and *Panorpa*, are drawn to the same scale, and indicate the relative size and abundance of the fine hairs and the scale-hairs among the four groups. The wing-covering of the Jugatæ is more specialized than that of the Trichoptera in two ways: (a), by the reduction in size, the degradation, of the fine hairs, tending toward

*The term "recognition character," used here and in the diagnoses of the suborders, may need a note of explanation. Professor Comstock refers to such characters as follows, in his essay (loc. cit.): "There will also arise, I believe, in a work of this kind a necessity for distinguishing between the essential characters of a group and those characters which are used by the systematist merely to enable students to recognize members of the group. For it seems to me that the essential characters of a group of organisms do not lie necessarily in the presence or absence of any structure or structures, or in the form of any part or parts of the body of the living members of the group: but rather in the characteristic structure of the progenitor of the group; and in the direction of specialization of the descendants of this progenitor.

"Thus, to use again the illustration given above, the Jugatæ are essentially characterized as the descendants of those ancient Lepidoptera in which the wings of each side were united by a jugum; and they are also characterized by a tendency towards an equal reduction of the veins of the two pairs of wings. While the Frenatæ are essentially characterized as the descendants of those ancient Lepidoptera in which the wings of each side were united by a frenulum; and they are also characterized by a tendency towards a greater reduction of the veins of the hind wings than of the forewings, or, in other words, by a tendency towards a cephalization of the powers of flight. The fact that in many of the Frenatæ the frenulum has been lost, does not invalidate in the least the truth of the characterization. The loss of the frenulum, however, in certain Frenatæ renders necessary the use of some other character or characters by the systematists as recognition characters."

that total disappearance which is characteristic of the Frenatæ; (b), a specialization, by addition, of the scales, which have, indeed, reached almost as high a degree of development as is to be found among the Heterocera. This high specialization of the scales in *Micropteryx* and *Hepialus* does not at all indicate a high rank for them among Lepidoptera, but is merely corroborative of the presumption that they are the existing tips of branches whose lower members have disappeared. Nor, indeed, is it necessary to believe that these branches have been long ones, for, as I show later, the specialization of scales can come about very rapidly.

It seems probable that the stem-form of the Lepidoptera possessed a wing-clothing much like that now exhibited by the Trichoptera, and and that the Jugatæ branched off before the covering of fine hairs had been lost, although the tendency of specialization had already become manifest. The phylogenetic position of the Jugatæ indicated by their wing-clothing quite corresponds with that suggested by the wing-venation as shown by Professor Comstock.

From these data regarding the generalized Lepidopterous scale it may be said that the generalized scale closely resembles a hair, but that it differs from the ordinary simple hair in its insertion. It is undoubtedly true that it is a modification of a simple hair, although this cannot be said to be proved from the data drawn from the phylogeny of the scale.

Entomologists from early times* have considered the scales to be modified hairs. The natatory, tactile, auditory, gustatory and olfactory hairs,† the frenulum‡ of moths' wings, and other variously appearing dermal structures are all modifications of simple hairs.

The testimony offered by the ontogeny of the scales is in confirmation of the conclusions drawn from a study of the phylogeny of the scales. It also practically proves the identity of the scale in its origin, with a hair. The ontogeny of the scale has been studied by Carl Semper,§ and his conclusions may be summed as follows: There are three stages in the development of the wing; in the first stage there is a pushing out of the epidermis of the body in the form of a double plate; in the second stage there appears a membrane which separates the lumen of the wing from the epidermis, which lies against the membrane: soon after this primitive membrane has become fully developed, the epidermis, whose cells have come to be

*In Reaumur's Histoire des Insectes, 1734, the author declares that hairs and scales are connected by intermediate gradatory forms.

†Lubbock, J., On the Senses, Instincts and Intelligence of Animals, 1838, New York.

‡Comstock, J. H., (loc. cit.).

§Semper, Carl, Ueber die Bildung der Fluegel, Schuppen und Haaren bei den Lepidopteren. Zeitschr. f. wiss. Zool., vol. 8, 1857, Leipzig.

large and cylindrical, draws away from the membrane, leaving a space between it and the membrane. In this space the beginnings of scale development appear. In the third stage of wing development the development of scales has fairly begun. In the space above described between the epidermis and the primitive membrane there are at short intervals large spherical cells with large nuclei, and which without exception bear, each, an elongate process which pushes out between the epidermal cells, and at first appears as a long stalk, which, however, suddenly widens into a more or less spherical bladder. This bladder is the first suggestion of the future scale. At first each bladder is large and irregular in outline. The long stalk is thus somewhat shortened. The free end of the forming scale gradually grows into a point which becomes longer and longer, while the body of the scale and the stalk become shorter, until finally a form is developed which compels recognition of its scale-like character.

It is a singular circumstance, says Semper, that not all of the scales are developed at the same time, but they develop one after another, so that one can often find the different stages of the scales on one and the same wing. But this disproportion is equalized by the scales growing more slowly in their later stages than in their earlier stages, and Semper noted that the scales attained their complete growth at about the same time.

Between this stage of scale development and that earlier stage in which the space between the epidermis and the primitive membrane which contains the developing cells of the scales was first apparent, there is a hiatus which Semper's observations were not able to fill.

In the same manner, says Semper, the development of the hairs of Lepidoptera proceeds, the hairs being completely identical with the scales. Semper observed the development of the antennal hairs of a male *Saturnia carpini*. These hairs arise, just as do the scales, from a layer of cylindrical cells. The hairs push out between the cells of the epidermis as do the scales, and the only difference in fact between the scales and these hairs is merely in the outer form; and this is no real difference, for there may be found between both forms numerous gradatory forms.

So long as no cuticle is developed by the epidermis the forming scale consists of a fine membrane which is a direct continuation of the parent-cell, and which contains a transparent finely-granular content, which is darkened and contracted by acetic acid. But as soon as the cuticle appears, one sees also developed on the scales and hairs—it was especially apparent on the antennal hairs of *Saturnia carpini*—a thickened layer which where the hair or scale meets

the cuticle of the epidermis of the antenna or wing fuses with it; the thin stalk of the scale which unites the scale with its parent cell secretes for a short distance between the cells of the epidermis such a thickened layer as renders the joining of the scale with its supporting membrane much more secure. At first one sees on the scales only a simple membrane, but soon longitudinal striæ develop in the following manner: at certain places a further thickening takes place on the secreting membrane, and proceeds till finally further depositing is limited to cross-striæ which develop between the separate longitudinal striæ. The scale is now complete except for the pigment, which in many species is deposited in the scale before its extrusion.

After the scale is fully developed, the parent-cell disappears, the granular content of the scale becomes absorbed, the primitive cell membrane dies out, and there remains only the chitinized cuticle of the scale, with its root fast in a pouch in the membrane.

The striking analogies between the course of development of scales and the varying conditions of the scales on the fully developed wing can not escape the reader's attention. It is to be noted that Semper's description of the formation of the insertion cups differs from that given by Landois, and quoted *antea.*

While a typical method of transition from scale-hair to flattened scale has been described on page 58, a study of the scales of various Lepidopterous forms reveals the fact that the transition from scale-hair to flat scale may follow other lines of gradation: that different modes of development of the scales are apparent in different groups of moths and butterflies: in a word that the scales present distinct lines of specialization which possess characteristics sufficiently marked to be recognizable by the student, and therefore to be to some extent available in taxonomic work.

The line of specialization exhibited by the scales of the Megalopygidæ is characterized by a splitting apart of the distal extremity of the scale-hair into two or more fingers, then a growing palmation between the fingers accompanied by a shortening of the proximal portion of the hair and of the distal fingers. The most specialized form in this line is a sub-triangular scale with apex at pedicel and the outer border or base of the triangle prolonged into three or four rather long fingers. The transition forms are well shown in figure 10.

Quite different is the line of specialization of the scales of the Cossidæ. The mode of transition from generalized form to specialized form can be observed on the hindwings of *Prionoxystus robiniæ.* Here the scale-hair first widens and flattens at its distal end; there is then a gradual shortening and an expansion for a considerable distance behind the tip so that there is formed an elongate sub-spatulate

scale, which continues shortening and widening, the point of greatest width coming nearer and nearer to the distal end of the scale. By this there results a more truly spatulate shape. The culmination of specialization is reached in a short, broad scale with rounding truncate outer margin, the scale being widest at its outer margin.

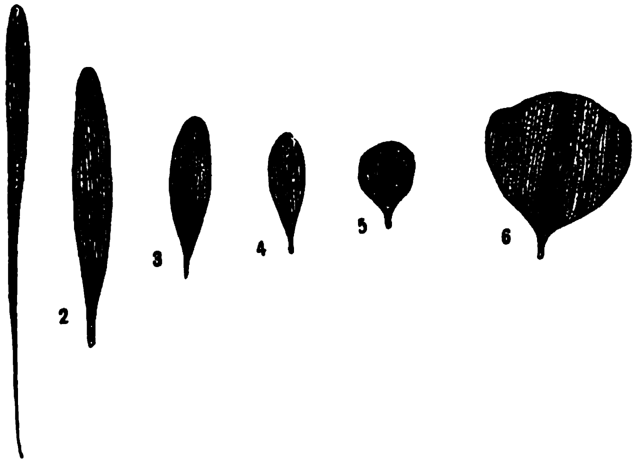


Fig. 11.

1, 2, 3, 4 and 5, scales from a single hindwing of Prionoxystus robiniæ: 6, specialized scale from forewing of same moth.

The outer margin is entire, no fingers or teeth appearing anywhere in the course of development. This outer margin is sometimes, in the specialized scales usually, gently and unevenly sinuate: in *Cossus* there is a shallow, rounding emargination at the middle of the outer margin so that the rest of the margin appears as two short, bluntly-rounding points or teeth. There may even be two emarginations so that three rounding teeth are formed. But these emarginations are a modification of the sinuation which appears late in the course of the scale's development and the "teeth" of the *Cossus* scales offer no reason for likening the scales of *Cossus* with those of *Megalopyge*. The transition forms of the scales of Cossidæ are illustrated in figure 11, all the scales figured having been taken from a single hindwing of *Prionoxystus robiniæ*.

Still another line of scale specialialization is that shown in *Gloveria*, and with certain modifications to be hereafter noted, pretty fairly characteristic of the family Lasiocampidæ. The scale-hair becomes a little flattened and widened; then it divides at its distal end into two fingers, the cleft not extending very far along the length of the scale; a shortening of the proximal portion of the scale and a widening of that part of the scale between the pedicel and the base of the two fingers is next apparent. Then one of these fingers divides near its base and a third finger is formed which grows out to be as long as

the other two; or both the original fingers send out shoots from their bases so that there are four fingers. The proximal portion of the

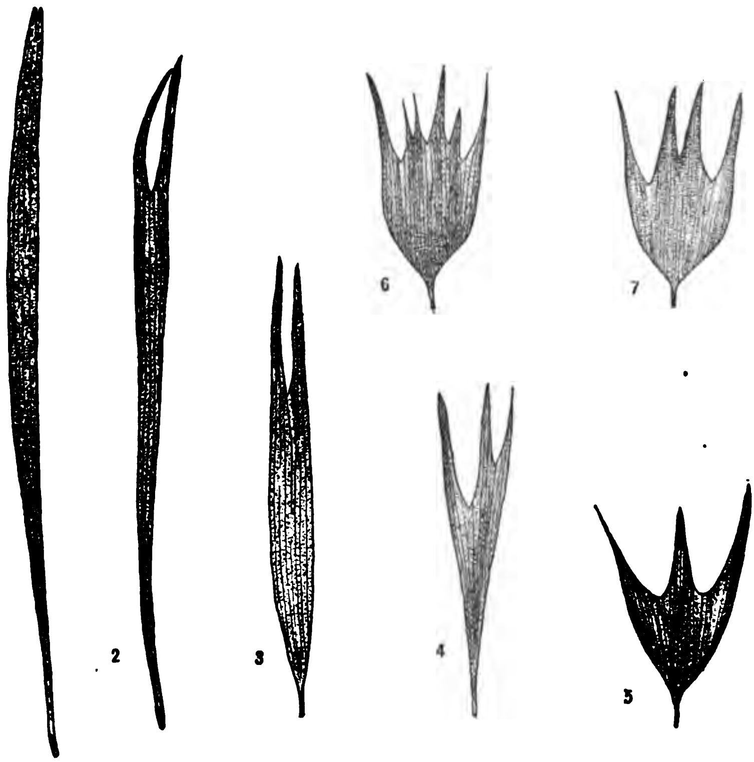


Fig. 12.
Scales from single forewing of Gloveria arizonensis.

scale is shortening all the time and the space between the pedicel and the bases of the fingers is widening. The number of fingers may increase to seven or eight, and the proximal portion of the scale become so short that the fingers are twice as long as the short, broad, blade portion. In *Tolype* the fingers may be three times as long as the uncleft portion of the scale. This line of specialization is illustrated in figure 12, a series of scales from *Gloveria arizonensis.*

Still another line of specialization is exhibited by the scales of *Heliconia.* The rather stout, not long, scale-hair appears next to be cleft almost to its base, the two fingers stiffly diverging. Then begins a widening and slight shortening of the fingers, the union of their inner margins proceeding farther and farther from the base, till there results a rather ovate scale with an angular emargination and two short, broad, acute-angled teeth on its outer margin. I have not been able to observe forms between the single-pointed scale-hair and the deeply cleft form shown as the second scale in the figure. As these generalized


Fig. 13.
Scales from single forewing of Heliconia sp.

forms of the scales on *Heliconia*, found on the apparently clear areas of the wings, are most likely results of a retrogression from specialized forms, the full course, or even true course, of the line of specialization may not be exhibited. The series illustrating this line, represented in figure 13, was taken from the forewing of one individual of *Heliconia* sp.

In attempting to understand the significance of these different modes of development of scales, these various paths leading from the generalized scale-hair to the specialized scale, it will be necessary to have in mind the distinction made by Professor Comstock in his essay previously referred to, between two kinds of characters which will be met with by the student in trying to work out the phylogeny of a group of organisms, viz.: "First, characters indicating differences in kind of specialization; and second, characters indicating differences in degree of specialization of the same kind. The former will indicate dichotomous divisions of lines of descent; the latter will merely indicate degrees of divergence from a primitive type."

Looking now at the development of the scales from this point of view, the gradatory series of scales taken from the Megalopygidae and the series from the Cossidae represent two different kinds of specialization, i. e., one a kind in which the change from generalized scale-hair to specialized scale comes about by a splitting of the distal portion of the hair into two or more fingers, then a palmation or filling in between the fingers until the extreme of specialization is reached in a shortened, flat scale with points or teeth projecting from the outer margin; the other kind in which the change comes about by a shortening and widening of the scale hair until there is finally a short, flat, wide scale with entire outer margin. The most specialized forms in each series are somewhat alike, and each has diverged from the primitive type in about the same degree. The characters indicating the different paths taken in reaching the specialized form are characters indicating dichotomous divisions of lines of development;

and the characters indicating the progress made along either one of these path toward the most specialized form are characters indicating degrees of divergence from the primitive type.

In examining the wings of many lepidoptera there will be found instances of a high specialization of scales which cannot be explained on the hypothesis of their strengthening function. There will be found scales of higher specialization in certain places on the disc of the wing than exist on the limb of the wing. These apparently exceptional instances of scale development are caused by the fulfilling of a second function by the scales, namely, that of ornament and the production of color and marking effects. This is an important function, but one necessarily secondary in line of development, in my belief, to the function of strengthening the wing-membranes.

The dependence of sharply-defined color markings on the specialization of the scales is marked. Among the lower moths where scale specialization has not proceeded far we rarely find such definiteness of coloring or sharpness of marking as among the butterflies where scale specialization is at its existing limit. Further, where among lower forms we do find cases of sharply separated color markings we discover a specialization of the scales within the limits of the color spots or lines much beyond the general condition of the wing-covering. In *Actias luna* the covering of the wing shows a conspicuous intermixture of long, slender, hair-like scales with the more specialized two- to three-pointed, short, flattened scales. The wings are uniformly pale green, except for a costal edging of maroon on the forewings (the marginal scales of the outer border of the forewings and hindwings are also maroon), and a conspicuous, sharply-limited eye-spot on each wing. The general wing-covering is evidently rather generalized, but the brilliant eye-spots are composed entirely, except for the clear pupil, of rather short, broad, short-pointed scales with no intermixture of scale-hairs, offering a striking contrast to the general loose, hairy covering of the wing. The clear pupil without scales, it may be noted, is directly over the discal vein. The long "tails" of the hind wing show a specialization of the scales on the under side near the tip. These specialized scales probably strengthen the membrane of the tails. In *Hyperchiria io*, which possesses a covering of lowly scales, and is rather uniform in color, a conspicuous eye-spot is present at the center of each hindwing. The eye-spot has a brown iris composed of scales about like the general covering, but the white pupil is composed of highly specialized scales. (With the white scales of the pupil are mixed many specialized brown scales).

The eye-spot on the hindwing of *Smerinthus cerisyi* is character-

ized by a more highly specialized condition of scale-covering within its borders, than is shown on the rest of the wing.

An example of the loss of sharpness in marking when the scales are not specialized is presented in *Citheronia regalis*. The covering of the forewing is pretty generalized, consisting of long one- or two-pointed scale-hairs and shorter, more specialized, three- to several-pointed scales. In the yellow spots which occur on the wing there is little or no difference of condition of the wing-covering, and the limiting or bounding of these spots is much less sharp than in the case of the color spots of butterflies. On the hindwings the covering is much more generalized than on the forewings, consisting almost entirely of long, soft scale-hairs. Here the yellow regions fade out into the reddish-brown ground with little definiteness of outline.

The colors of scales are produced by two causes: (1), the presence of pigment; (2), the overlapping, lamination and striation of the scales which produce those familiar but striking optical phenomena due to the interference of the waves of light. These two sorts of colors have been called by Hagen "natural colors," referring to the colors due to absorption of waves of certain lengths and the reflection of the others by pigment, and "optical colors," due to wave interference incident to reflection through the laminæ and striated surfaces (diffraction gratings) of the scales. Combinations of these causes are usually present so that the resulting color effects are practically incapable of analysis.

As the pigments mostly transmit the same colors as they reflect (the colors complementary to the colors absorbed) the colors of scales which produce color by pigments are usually the same by transmitted light as by reflected light. But in the case of "optical colors" (colors by interference of reflected rays) this is not the case. The scales producing these colors are often transparent, as with *Micropteryx*, and these when viewed by transmitted light are colorless, or they contain pigment and when viewed by transmitted light a color is seen which is due wholly to the pigment and not at all to the structural features (lamination and striation) so that it may be entirely different from the colors seen when the scales are viewed by reflected light.*

Where the scales do not overlap they present two superposed lamellæ (the opposed cuticular sides of each scale); where they irregularly overlap there are at some points two and at other points four superposed lamellæ; and where the scales are arranged in double-tiered

*An interesting experiment is to take a wing of *Lycæna* or *Morpho* and examine it under the microscope by reflected light and by transmitted light. In examining by transmitted light care should be taken to prevent any light falling on the wing from above. The colors will be very different by the two lights.

rows and the scales of one row partially overlap the scales of another there may be from two to eight superposed lamellæ at various regularly recurring points on the wing. These superposed scale-lamellæ produce colors by interference just as the familiar colors are produced in the case of soap-bubbles, oil-films on water, or where there are other thin layers of transparent substances.

In addition, the striæ-bearing surface of the scale, being composed of thickened opaque lines with transparent interspaces, is essentially the same as a ruled surface or grating, producing the interference phenomena of diffraction. The finest of Rowland gratings possesses lines slightly exceeding 1000 to the millimeter. The striæ of the transparent scales of *Micropteryx* are from about 500 to 300 to the millimeter, varying in different species. The opaque scales of *Morpho*, which show metallic reflections, have about 1400 striæ to the millimeter.

The colors due to interference are those brilliant metallic or irridescent tints especially common among the butterflies, as in *Morpho* and *Lycæna*. But it is rare that these interference effects constitute all of the colors of a lepidopterous wing. This, however, is the case in *Micropteryx*, where all the scales are transparent and colorless. Usually the nearly transparent scales producing interference effects are colored, and commonly there are both opaque and transparent scales on the wing. Unless all the scales on a wing are opaque, absorption colors or "natural colors" cannot be the sole color of a wing. For wherever there are transparent or subtransparent scales on a wing, from the uniformly laminated and striated structure of all ordinary lepidopterous scales, interference effects are bound to exist.

These color effects of the scales have been a favorite subject of investigation and speculation by entomologists, and a host of observations are recorded. Many attempts at classifying the colors, and the causes of them, have been made. In a paper of much value presenting the results of a detailed study of coleopterous scales, Dimmock* lays much stress on the constant presence of air in the scales, as influencing the color.

It is evident that the color spots or lines can have much better defined, sharper and more constant limits when the scales composing the color spot or line are short, firm and plate-like than can be the case when the scales are long, hair-like and flexuous. A uniform arrangement of the scales would help much, also, in the formation of sharp boundaries for the color-markings.

In addition to the definiteness of color-marking possible with flat,

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*Dimmock, Geo., The scales of Coleoptera, Psyche, vol. 4, 1883, Cambridge, Mass.

stiff scales and a regular arrangement of them, such specialized scales much better serve to produce those striking colors due to interference, than do the generalized scale-hairs. And a uniform arrangement, by bringing about regular overlapping, also aids in the production of these colors. So that for the best performance of the color function (the production of sharply-defined color-markings and of brilliant tints) a specialization of the wing-covering is desirable, which, both in form of the scales and their arrangement, is quite parallel or identical with that specialization which best subserves the function of strengthening the wing-membrane.

As color-markings exist among Lepidoptera for protective resemblance or for attractive ornamentation,* in a word, for use, day-flyers would of course, present a special development of color. In the day-flyers the function of the scales as color and marking producers is of great importance. It is probable that the great specialization of the wing-covering of the butterflies is more dependent on color function than on the strengthening function. This very specialization of the scales, though, for color effect, moving along the same lines as the specializing for strength, brings it about that both functions are the best subserved in these specialized day-flying Lepidoptera. It is true, at any rate, that the specialization of the wings of butterflies (shown by venation) for powerful flight such as possessed by the Sphingids and some Zygænids is not comparable with the wing specialization of these Sphingids and Zygænids. The butterflies have a flight peculiar to themselves, however, which is very effective in saving them from capture while on the wing, and which, as a kind of flight especially adapted to their needs, is accompanied by a distinct line of venation specialization.

The specialization of the scales on the wings of Lepidoptera under the special influence of their color function, will accompany those advantageous occurrences of color and markings which are exhibited among the moths and butterflies. For example, in the Arctiidæ there are many forms in which the forewings show a considerable amount of color-marking or pattern while the hindwings, which are quite covered by the forewings when the moth is at rest, are without pattern. The scale-covering of the forewings in these cases, as in *Halesidota argentata* and *Arachnis picta*, is more specialized than that of the hindwings. This, however, would be expected because of the greater importance in flight of the forewings, accompanied by a

*It is probable that the patterns of Lepidoptera are not the result of sexual selection, i. e., are not for attractive ornamentation, considering the poor eyesight of these insects. More likely the colors and patterns are the result of natural selection, producing the familiar conditions of mimicry for protection.

specialization of the scales for strength, as previously pointed out. But the scale-covering of the forewings of these patterned forms is more specialized than that of the forewings of certain other Arctians which do not exhibit a considerable degree of color-marking, as *Euchætes*, where the forewings are of uniform dull-grayish color. Now the specialization of the wings for flight (shown by venation) is practically the same for these two Arctiid genera, so that the increase in specilization of the scales of the forewings of *Halesidota* and *Arachnis* over the condition shown by *Euchætes* is to be correlated with the patterns and color-markings of the first two examples and the absence of such markings in *Euchætes*.

Again, the hindwings of *Euprepia* and *Epicallia* show vivid and sharply defined color-markings; and correspondingly the scale-covering of these wings is more specialized than the scale-covering of the hindwings of *Halesidota argentata* which are not patterned. This difference of scale-specialization among these related forms is evidently to be correlated with the color-function rather than with the strengthening function of the scales.

Among the butterflies, who when at rest hold their wings together over the back so that the under sides of the wings (chiefly of the hindwings) show, the under sides of the wings present distinctive and complex color-markings, the pattern of the under side of the hindwings being often more elaborate than that of either surface of the forewings.* There is correlated with this a condition of wing-

*An excellent example of the effective marking of the under sides of the wings is shown by *Argynnis nevadensis meadii*. The upper sides of the wings are patterned in black and brown according to the familiar Argynnid type. When the insect is flying, this black and brown pattern constitutes the chief visible coloration of the butterfly. On the under side of the hindwing the brown ground is so suffused with greenish as to be practically mottled pale green; there are also the usual large silvery spots or blotches. A similar greenish ground with smaller silvery spots occurs on a considerable triangle at the apex of the forewing (under side) and the greenish extends along the costa to the base of the wing, and along the outer margin to the anal angle. The rest (the disc) of the wing is brown and black much as on the upper sides of the wings. When the wings are folded above the body, upper sides opposed, the hind wing covers all of the brown and black space of the under side of the forewings but does not cover the apex, the costa and the outer margin which are greenish: so that when the butterfly is at rest with its wings folded the entire visible portion of the wings is a greenish ground with silvery spots, quite a different color and pattern from that presented by the flying insect, but one undoubtedly much more in harmony with its terrestrial surroundings. The interesting thing in the case is that only that portion of the under side of the forewing which is exposed when the wings are folded has acquired the greenish ground: the part of the surface unexposed possesses a color and pattern like that of the upper sides of the wings. Is the brown and black the first acquired color and pattern? It is plain that selection would have no tendency to change the color of this unexposed part of the wing surface, and this color, thus, probably represents the original color and pattern of the whole under side of the wing. It also adds to the general brown and black effect of the flying insect that this considerable portion of the under surface of the forewing is brown and black; while it would not at all add to the greenish and white effect of the motionless insect if this portion were greenish and white.

A similar distinctive and striking coloration of the under sides of the wings is shown by *Pieris beckeri*, a mountain Pierid first taken in Virginia City, Nevada, on flowers of *Brassica*. The wings are mostly white above, with a few black spots, mostly gathered at the apex of the forewing. The under side of the hindwing has a white ground with many rather elongate rectangular spots of greenish, the greenish color covering more of the wing-surface than the white. The apex and outer margin of the under side of the forewing is marked as the hindwing, while the disc is white with a black spot. When the butterfly is at rest the color effect is yellowish-green modified by white a coloration probably effectively protective. The white disc with black spot on the under side of the forewing is concealed when the butterfly is at rest, and therefore does not share the otherwheres general greenish color of the under sides of the wings.

covering on the under sides of hindwings in butterflies little or not at all less specialized than that of the upper side of the forewings. Such a condition is rarely found among the moths where the under sides of the hindwings are much less important as a pattern-carrying surface. To be sure the specialization of the scales as a whole on the wings of butterflies, front and hindwings, upper and lower sides, is much more advanced than almost any scale-condition among the moths, but the difference in degree of specialization between the scales of the forewings of butterflies is much less than the difference between the scale-specialization of the fore and hindwings of moths, while the difference between the importance of the flight-function in the fore and hindwings of butterflies as indicated by the venation is approximately equivalent to the usual difference in flight-function between the fore and hindwings of moths.

The clear spaces in the wings of certain moths and butterflies, as the Sesiidæ and certain Zygænids and Heliconids, are to be explained, not by presuming a generalized condition, a primitive state in which scales have not yet developed, but rather a specialization by degradation for purposes of ornamentation or imitation. The most generalized Lepidoptera possess scales, and in addition a covering of fine, fixed hairs. The forms possessing these clear areas are among the more specialized Lepidoptera, and therefore if without scales must have lost them. The clear areas never exhibit a covering of fine, fixed hairs. The statements of various writers* that these clear spaces in certain forms (as *Heliconia*) are sparsely covered with hairs, is true, if we bear in mind that these "hairs" are the generalized scales, always inserted in insertion cups, and wherever at all flattened showing the characteristic longitudinal striation of the scale.

In an exotic Heliconian, the wings, mostly clear, show a covering of comparatively widely scattered scale-hairs, gradating into the specialized scales of the scaled areas of the wings, but there are no fine, fixed hairs (i. e., as those of the Jugatæ and the Trichoptera) present in these clear areas. The scales in these clear areas have faded out, and in so doing exhibit a series of gradatory scale-forms, by retrogression, which may illustrate the mode of original progression of specialization of the scales in these lepidopterous forms. A gradatory series of scales from the exotic Heliconian just referred to is shown in figure 13, page 67. Among the butterflies, the scales are so

*Kirby and Spence say (Introduction to Entomology, vol. 2, p. 641): "But though the general clothing of the wings of Lepidoptera consists of these little scales, yet in some cases they are either replaced by hairs or mixed with them. Thus in the clear parts of the wings of Heliconians, Attaci, etc., short inconspicuous hairs are planted; in a large number of the orders the upper side of the anal area of the secondary wings is hairy." The authors here refer to the scale-hairs, the scale in its generalized or degraded condition.

Burmeister similarly calls attention to the hairs ("*poils*") in the clear areas of the wings of *Ithomyiia*, a clear-winged Heliconid.

uniformly specialized, that it is often only through such exhibitions of retrogression as the above that the line of specialization of the scales can be determined.

In *Hemaris thysbe* and among the Sesiidæ the clear areas are quite destitute of covering. It seems evident that this disappearance of scales is one of the adaptive changes accomplished during the long process of selection which has resulted in giving the Sesians their familiar and striking superficial resemblance to wasps and bees, a protective resemblance of evident value. Among the Attacids, the clear spots on the wings of *Promethea* and *Luna* are without scale-hairs; in *Samia cynthia* the clear spaces are covered with scale-hairs which rather plainly gradate into the scales of the scaled areas. In *Cosmosoma* and *Didasys*, clear-winged Zygænids, the clear areas are sparsely covered with scale-hairs which more or less clearly show a gradation into the specialized scales of the scaled areas. The absence of scales from the major portion of the wings of these clear-winged forms shows that by a thickening of the wing-membrane or by adapted venation, a substitute for the scale-strengthening has been developed; or that the advantage of protective resemblance gained by the disappearance of the scales is greater than the advantage gained by the presence of the scales to strengthen the wing-membrane.

The scales of Coleoptera, however they may have arisen, serve solely now, probably, for producing color and marking. Occuring, as they do, chiefly on the horny elytra they apparently have no present strengthening or protecting function. Scales are present in many groups of beetles, being especially often met with among the Curculionidæ. Fischer* found scales among the Cleridæ, Ptinidæ, Dermestidæ, Byrrhidæ, Scarabæidæ and Curculionidæ. Dimmock* adds to these families containing scale-bearing forms the Elateridæ, Cerambycidæ, and "with some doubt, the Buprestidæ."

In a Brazilian Curculionid examined by me the body of the beetle was bronze-golden and white with occasional small, shining, black tubercles on the elytra and pronotum. These black tubercles were without scales, but the golden and white colors were caused by small elongate scales. These scales were not arranged on the body in regular rows, but were sufficiently numerous to overlap considerably. The white scales were flattened elongate with nearly parallel sides, entire outer margin, and bore striæ about .006 mm. apart. The golden scales were about .286 mm. in length, .043 mm. wide near insertion of pedicel and .028 mm. wide at outer end, and bore striæ

*Fischer, L. H., Microscopische Untersuchungen uber die Kaeferschuppen. Dissertation, Freiburg. 1846.

†Dimmock, Geo. The scales of Coleoptera, Psyche, vol 4, pp. 3-11, 23-27, 43-47, 63-71. 1883, Cambridge, Mass.

about .005 mm. apart. Both white and golden scales were pigmented so as to be almost opaque. The colors produced were the effect of both absorption (pigment) and interference (striæ and laminæ). The scales were pediceled and inserted in little pockets, and essentially like the scales of Lepidoptera.

The scales from another exotic Curculionid were small, flattened and irregularly orbicular in outline. One scale was .077 mm. wide at widest part and almost exactly the same in length, and appeared to be irregularly facetted on the surface; a condition which would be another aid to the production of color effects by interference.

There are often scales on the dorsum of the cephalothorax and abdomen of spiders, especially among members of the family Attidæ. The cephalothorax and abdomen above of a specimen examined were covered with the scales though these scales were not arranged in regula rows. The scales were flattened, pediceled but not striated. The surface of the scale bore, however, small raised points or projections at rather regular intervals.

As with the scales of the wings, the body-scales serve for two uses, one, a strengthening and protecting, and the other, the production of color and pattern. The more apparent covering of the lepidopterous body is a close aggregation of generalized scales, long, slender, hair-like, sometimes producing a "wooly" covering, as in *Megalopyge* and many Saturnians. Or there may be an intermixture of hair-like scales and scales of more specialization, as most commonly occurs; or the body scales may nearly all be of considerable specialization, and be closely appressed to the body, as among the rapid-flying Sphinges, and the brilliantly-colered Sesians.

A specialization of the body-scales, the scale-hairs being broadened and flattened and closely appressed to the body, forming a smooth continuous coat, as of mail, over the body, would certainly be of advantage to a swift-flying moth, inasmuch as the resistance offered by the air to such a smoothly mailed body would be less than that met with by a body loosely covered with a mass of assurgent hairs. Such a condition of the body-scales is shown by *Philampelus* and *Chærocampa.* The protection given to the body by such a coat too, cannot be inconsiderable. In these swift-flying Sphinges the shape of the body, the venation of the wings, and the specialization of the scales of body and wings are all correlated with the fine flight of these moths.

The specialization of the body-scales is, perhaps, especially apparent in connection with the color-function. Among the Sesiidæ the bodies are often colored in lines and spots, the limits of the colored areas being well defined, and among these moths the highest specializa-

tion of body-scales among the Lepidoptera occurs. These moths are also good flyers, and a specialization of the body-scales might be looked for on that account. But the scale specialization is markedly beyond that of the rapid-flying Sphinges, whose bodies are not so variably colored and marked, which suggests that this specialization has been brought about by the combined influence of the advantage derived from both functions.

It is plain that the same general course of specialization from flexuous hair-like form to short, flattened scale as presented by the wing-scales, obtains in the case of the body-scales. The specialization of the scales of the body is usually inferior to that shown by the wing-scales.

The function of protection as performed by scales is especially illustrated among the Thysanura. The two genera *Scira* and *Entomoteria* are distinguishable only, structurally, by the presence of a body-covering of scales in *Scira* and the complete absence of scales in *Entomoteria*. With this structural difference is correlated the physiological difference that *Scira* commonly lives about houses, under dry boards, and generally in exposed places; while the rare *Entomoteria* is only to be found beneath stones, under the bark of trees, and generally in secure and protected places.* The scales manifestly protect the tender body of *Scira*, and allow it a wider and freer range of habitat.

Still another function subserved by the scales is that of acting as the external openings of scent glands. For a long time scales of peculiar shape and structure and usually much smaller than the ordinary scales occurring on the wings of the males of certain species of butterflies have been known to entomologists aud microscopists. These scales have been called "plumules" or "battledore scales," and more recently "androconia." Deschamps† in 1835 described many forms and gave a list of 37 species (belonging to 3 genera) of butterflies upon which he found these plumules. He credits the discovery of these peculiar scales to Baillif. Several English microscopists, notably Watson,‡ Wonfor,§ and Anthony‖ have studied and described various forms of these scales. Scudder** has figured a large number of these androconia.

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*For this information regarding the structure and habits of *Seira* and *Entomoteria* I am indebted to Mr. A. D. McGillivray of Cornell University.

†Deschamps, Bernard, Recherches microscopiques sur les ailes des Lepidopteres. Ann. des Sci. Nat., tome 3, 2 me. Serie, 1835, Paris.

‡Watson, J., Papers on plumules or battledore scales, in Mem. Lit. and Phil. Soc., Manchester, 1865; and in Entom. Mo. Mag., 1865.

§Wonfor, F. W., Papers on butterfly scales characteristic of sex, in Quart. Jour. Micros. Soc., 1868, 1869.

‖Anthony, J., Papers on battledore scales, in Mo. Micros. Jour., 1872.

**Scudder, S. H., Butterflies of the Eastern United States and Canada, vol. 3, plates 46-51, 1889, Cambridge, Mass.

Among the Nymphalidæ the androconia are usually long, slender and feathered at the tip, (see fig. 14); in the Pieridæ they are usually fringed at the apex, and heart shaped at the base, the pedicel being peculiarly developed into a slender stem with a ball at its tip (see fig. 15); in the Lycænidæ a battledore shape is presented, the scale usually being quite small (see fig. 16). The androconia are found almost without exception on the upper side of the wings, and are more commonly met with on the forewings than on the hindwings. They are often found in certain limited spots, or in folds of the wings. This is usually the case among the Nymphalidæ, a familiar example being the pouch of the hindwings of *Danais archippus*. Among the Papilionidæ they are limited to folds on the wings, as those folds along the inner margin of the hindwings of *Papilio*. In the Hesperidæ the androconia are found in costal folds or in the familiar discal spots or streaks. Among the Lycænidæ and Pieridæ they are most often scattered over the wing-surface being concealed in the general wing covering.

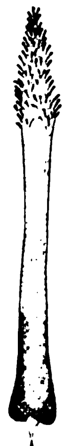


Fig. 14.

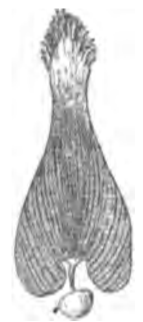


Fig. 15.

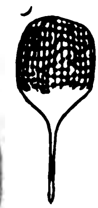


Fig. 16.

Androconia from the wings of male butterflies.

The function of the androconia was first made out by Fritz Müller* to be that of external parts of scent organs. Müller gave a long list of species who give off odors by means of scales.

That male butterflies may possess odors and that these odors come from scales, can be confirmed by catching a male of our common Imported Cabbage Butterfly (*Pieris rapæ* L.) and after rubbing the upper surface of the forewing with the finger, smelling of the finger-tip. A distinctly pleasing aromatic fragrance is apparent. Odors cannot be made out by human olfactories in many cases of the occurrence of androconia, but it is probable that it is because of the limitations of the human ear rather than because of an absence of odor, and odor may be pretty fairly attributable to any form possessing androconia.

That the androconia may act as scent organs it is necessary that they be still connected with the metabolic processes, and therefore with the living tissues of the lepidopteron. This is not the case with the ordinary scales. Weissmann† has shown that living cells are

*Muller. Fritz. See notes on Brazilian Entomology, Transactions London Ento. Soc. 1877. London. Ueber Haarpinsel. Filzflecke und aehnliche Gebilde auf den Fluegeln maennlicher Schmetterlinge, Jenaisch. Zeitschrift f. Naturwiss. vol. 11. 1877, Jena; and other papers.

†Weissman, August, Ueber Duftschuppen, Zool. Anzeiger, 1878, Leipzig.

present in the wing substance, and Prof. Mason B. Thomas* has demonstrated the existence of glands in the wings and their direct connection with the androconia in *Danais archippus*, *Thecla calamus*, et al. Under such a condition the scent-stuff passes up from the gland through the pedicel of the androconium, and is dissipated from the feathery tip or the scattered lateral openings of the scale.

The specialization of androconia is therefore a distinct modification of the scale or hair. The scarcity of the scent-scales, however, compared with the ordinary scales, and their ease of recognition renders them but little likely to confuse the student endeavoring to discover the state of specialization of the general wing-covering of a lepidopteron. Their presence, however, it must be noted, is often accompanied by a specialized development in size and shape and arrangement of a considerable number of the ordinary scales adjacent to the androconia and serving to protect or conceal the scent-scales. The very large scales overlying and concealing the androconia along the cubital and anal veins of the forewings of *Argynnis idalia*, and the large assurgent scales often noticeable in the androconia-bearing patches or spots of Hesperids are example of this.

Scent-organs are also known on the bodies of Lepidoptera, especially among the moths. Von Reichenau† finds the privet and pine hawk-moths to be provided with a special scent-organ at the edge of the lower side of the first abdominal segment; it comes into view on pressure of the abdomen of the dead or living insect, and consists of two symmetrical bunches of hair-shaped scales, which may be extruded or drawn in. When they are extruded in a living *Sphinx ligustri* a distinct musky scent is apparent at the distance of half a meter; but ceases to be apparent when they are retracted into their fold, which occurs when the insect is at rest. Only a rudiment of this organ is present in the female.

Prof. P. Bertkau‡ has studied the scent-organs of various German Lepidoptera. The Noctuina have ventrally placed organs of the Sphingid type. In *Hadena* and *Dichronia* the hairs of the tuft are extraordinarily long; there is not, as in the Sphingidæ, one scale on one large gland-cell, but several smaller cells belong to one scale. A very similar apparatus was found in some Orthosiidæ.

Scales probably subserve still another function, namely, that of producing sound by stridulation. According to Haase certain hard scales on both sexes of the Indian genus *Hypsa* appear to produce a

*Thomas, Mason B., The androconia of Lepidoptera, American Naturalist, vol. 27, no. 323, p. 1018, November, 1893.

†Von Reichenau, W., Kosmos, IV, 1880, p. 387; abstract in Jour. Roy. Mic. Soc., series 1, vol. III, p. 938, 1880.

‡Bertkau P., Verh. Nat. Ver. Preuss. Rheinlande, XLIV, 1887, pp. 118-119; abstract in Jour. Roy. Mic. Soc., series 2, vol. 8, p. 406, 1888.

shrill sound, as otherwise occurs in the male of *Thecophora fovea* and in the male of the Indian *Caristes membranacea*. Scudder (Butterflies of the Eastern United States and Canada) has heard *Vanessa antiopa* make a grating sound while fanning its wings together, and he artificially produced this sound after the death of the butterfly by rubbing the wings together. *Inachis io* and *Parnassius apollo* have been heard to make sounds while moving the wings, presumably scraping them together.

## V.

In the light of the observations just recorded on the structure, functions and development of the scales of Lepidoptera, we may reasonably attempt to derive from the conditions of the scales in various lepidopterous species and groups, the testimony which the scales bear as to the phylogeny of lepidopterous forms. In a word, we may attend to the taxonomic value of the scales.

The characters possessed of taxonomic value, or value of the characters for the classification of the organisms, are not merely those characters by which one species or group of species may be recognized at glance to be different from other species, but, more truly, are characters which indicate lines of specialization and thus lines of descent, i. e., phylogenetic relationships.*

Any organ of the insect body has reached its present condition only by gradual and constant specialization. This specialization may be in the nature of an additional development of the organ so that it may more effectually perform its function, and usually is; as in the specialization of a weak, flexible hair to a strong, flat scale, the function being that of strengthening a delicate membrane. Or the specialization may be in the nature of a degradation or retrogression of the organ by reason of a doing away with the need of the functions of the organ, and consequently with the need of the organ itself.

Or the organ may be thus degraded when its function is performed by a substitute for it; or when its function is of less importance, less advantage, than some other condition or need which would be impaired by the presence of the organ. This latter case is exemplified in the retrogression and fading out of the scales from the clear areas of the Sesiidæ and other similarly mimicking Lepidoptera.

The various functions, also, fulfilled by scales, render the interpretation of their phylogenetic significance the more difficult, as the state of specialization may depend now on the value of one function and now on another. Practically, in considering the scales, but two functions are thus complicated, namely, those of strengthening the

*For a discussion of the significance of characters, see p. 61.

membrane and of producing color effects. The function of giving off scent is confined to scales whose peculiar structure allows them to be readily identified and considered apart.* The specialization of scales for strengthening organs and for color-producing organs follows the same general line, so that a confusing complexity, brought about by specialization for two needs tending to similar structural results, confronts the student.

Finally it has been sufficiently shown that the specialization of scales may come about very quickly. On a moth showing the most generalized of scales there may exist scales of considerable specialization. And on but very few moths is there anything like a covering wholly composed of generalized scales. A considerable degree of specialization is attained by the scales, among even the more generalized Lepidoptera, so that the covering of a wing must be looked at as a whole, and an average condition, as it were, determined, rather than its being possible to learn much from a few scales taken at haphazard from the wing.

Thus it is that recognition characters calculated to be easily available to the systematist will not often present themselves in the wing-covering of the Lepidoptera, while nevertheless the scales may afford indications of real value regarding the phylogenetic relationships of various forms.

## The Lepidoptera.

Wings bearing a covering of fine, fixed hairs (from .005 mm. to .03 mm. in length) in addition to the covering of specialized scales ............................ Suborder JUGATÆ.

Scales pigmented and showing a coarse and a fine striation ........................ Family Hepialidæ.

Scales transparent, with uniform striation ........ .......................... Family Micropterygidæ.

Wings not bearing a covering of fine, fixed hairs in addition to the covering of generalized or specialized scales ........ .................................... Suborder FRENATÆ.

### THE JUGATÆ.†

The Jugatæ are distinguished from the Frenatæ, according to the wing-covering, by the presence in the Jugatæ and its absence in the Frenatæ of a covering of fine, fixed hairs (the hairs never more than .03 mm. long) on the upper and under surfaces of the fore and hind-

*In connection with the occurrence of androconia the form and arrangement of contiguous scales may be considerably affected in order to conceal or enclose the scent-scales. But such exceptional conditions are usually unmistakably apparent as exceptions to the general condition of scale-development on the wing.

†For an account of the establishing of suborder Jugatæ see p. 60.

wings, in addition to the covering of scales. (For a detailed account of the characteristic wing-covering of Jugatæ, see pp. 60, 61.)

This covering of fine hairs is the persistence of a primitive wing-covering, probably approximately represented in the wing-covering of the living Trichoptera. These fine, fixed hairs are wholly wanting in the Frenatae, having disappeared in even the most generalized of the living Frenatæ. This suborder comprises two families, the Hepialidæ and the Micropterygidæ.

### HEPIALIDÆ.

The only North American genus of the family is *Hepialus*. The moths of this genus are mostly dull-colored, without sharply defined color-markings. There should be excepted the silvery white spots present on the forewings of a majority of the species. These white spots are sharply delimited, and are caused by scales containing air. The ground color of the forewings varies from grayish-brown to testaceous to reddish-brown, and the markings consist of broad irregular bars and large uneven blotches. The hind-wings are almost uniformly dully uni-colored, rarely exhibiting indistinct markings at the apex, as in *argenteomaculatus*

The scale covering of the hindwings is markedly less specialized than that of the forewings, the advance of the forewings depending doubtless on the special development of color-markings, as the venation of the fore and hindwings is almost identical, so that the flight-use of the wings is about equal.

The line of scale-specialization in *Hepialus* appears to be this: The long scale-hair flattens, widens and shortens; the tip shows an angular emargination, a shallow dividing; the widening and shortening of the scale-hair continues, and there is a further dividing at the tip into three or four or five short, sharp-pointed wide-based teeth. The scales are pigmented and show what may be called a double striation; i. e., a few coarse, heavy striæ are interspersed among the more numerous ordinary fine striæ. In dentate forms there are as many heavy striæ as there are marginal teeth, each stria terminating in the point of a tooth. This double striation is not plainly apparent in some of the scales when they are mounted dry, but is well brought out by mounting in balsam. Whether these coarse striæ are due to an extra thickening or folding of the cuticular membrane, or by a special aggregation of pigment granules in regular lines is undetermined.

The specialized scale, therefore, in a majority of the species of *Hepialus* is rather elongate, with a few short, sharp-pointed, wide-based teeth on the outer margin. The scale is pigmented and doubly

striated, i. e., possesses a coarse and a fine striation (see fig. 7, p. 51). In *argenteomaculatus* and its variety *purpurascens* the outer margin of the scale is not dentate, but is obtusely rounded or truncate, with faint emarginations, feebly sinuate, it might be called. The scales of *humuli* have a rounded tip with very short, irregular points; *behrensii* has a single emargination in the middle of the outer margin, thus forming two lateral teeth.

### MICROPTERYGIDAE.

The only genus in this family is *Micropteryx* which is represented in North America by five species. The moths are very small, being among the smallest of the micro-lepidoptera. The forewings show striking irridescent colors; the apex of the hindwings also exhibits these metallic reflections. A bronze or almost golden tint is the commonest; next in point of common occurrence come violet or reddish-purple reflections. On the hindwing rarely more than the apical one-third is brilliantly colored, the disc and base being of a cloudy sub-transparency. Both fore and hindwings are fringed with long scale-hairs on the outer and anal margins, or parts of them; also on the apical one-third of the costal margin. The fringing varies greatly in the length of the composing scale-hairs and in the extent of wing-margin on which it occurs. The scale-hairs projecting caudad from the anal margin of the hind wing are sometimes as long as the whole breadth of the wing (costal to anal margin).

The scales are plainly formed on one plan, and no distinctions of much worth can be made out among the scales of the various species. The state of specialization reached is high, and considering both fore and hindwings the scale-specialization shows a uniformly greater divergence from the primitive type than that of *Hepialus*. This is especially apparent in the scale-specialization of the hindwings.

The mode of scale-specialization is not clearly shown: It seems that the scale-hair grows wider and shorter without any division at the tip, a specialized scale thus resulting with entire outer margin. The form of the specialized scales differs from elongate to almost orbicular types; the outer margin is rounded or truncate or obtusely-angled in the middle. Gradations among all these three outlines of the tip may be found in almost every species; though the majority of the scales taken from the disc of the forewing of a certain species, A, will be truncate, on species B the margin will be obtusely-angled, and on species C the tip will be rounded. The rounded tip is by far the most common. There is considerable variation in the size of the scales, and the extremes of variation in size and outline present among the scales of the genus may often be found in one species.

The scales of the wing-surface (excluding marginal scales) are uniformly transparent, and are distinctly and beautifully striated. The striæ are as nearly truly parallel as any observed by me, and on a given scale are very uniform as regards their distance from one another.

On the hindwings the scales are less specialized in form, indicated by their long, slender outline, than on the forewing. They are less numerous, too, overlapping but little. Towards the apex of the hindwing with the beginning of the metallic colors, the scales are shorter and broader, more abundant and overlap conspicuously.

Some details of outline and size and condition of striation are briefly given, as follows:

*M. seppella* (?):--Scales rounding or obtusely-angled at the tip; lateral margins sub-parallel till near base; length of an average scale, .0757 mm.; breadth, .037 mm.; distance between striæ, .0023 mm.

*M. chrysolepidella*:—Scales rather elongate, apex slightly rounding or truncate; lateral margins sub-parallel or slightly converging near base; length of an average scale, .117 mm.; breadth, .0486 mm.; distance between striæ, .0025 mm.

*M. fastuosella*:—Scales very large; apex truncated to slightly rounded; lateral margins usually converging posteriorly, apex, or region near it, therefore, the widest part of the scale; length of scale of maximum sixe, .24 mm.; of a scale of minimum size, .10 mm.; breadth of an average scale, .075 mm.; distance between striæ, .0027 mm.

*M. mansuctella*:—The striae are specially far apart in these scales, an average distance between striæ being .0428 mm; the length of an average scale, .0914 mm.

## THE FRENATÆ.

The Frenatæ, including all the families of the Lepidoptera excepting the Hepialidæ and Micropterygidæ have been subdivided by Prof. J. H. Comstock into two groups, viz.: the "generalized Frenatæ" being a group of families which "are suppdsed to retain more nearly than any other Frenatæ the form of the primitive Frenatæ, those that were the first to appear on earth," and the "specialized Frenatæ." The venation of the wings affords, in the persistence of the median vein in one or both pairs of wings and of two or three anal veins in the forewings, and three anals in the hindwings, a means for distinguishing these generalized families.

### THE GENERALIZED FRENATÆ.

The "generalized Frenatæ" include the small families, Megalopygidæ, Psychidæ, Cossidæ, Parasidæ and Pyromorphidæ. The

conditions presented by the scales in these families correspond well with the lowly rank accorded these families on the evidence presented by their venation. It is instructive as showing the indications of phylogeny afforded by the scales to compare scale conditions presented in the "generalized Frenatæ," with those presented by the butterflies, the most specialized group of the Frenatæ.

Among the generalized Frenatæ the scale-covering is sparse (except perhaps in the "wooly-winged" Megalopygidæ). Scales of very generalized condition are found on almost all the species (in *Megalopyge* the whole scale-covering is composed of generalized, weak, hair-like scales) and there is none of that fine order of arrangement of the scales into rows and tiers, so as to form a complete, evenly-disposed sheath over the wing-membranes as presented characteristically by the butterflies. Among the butterflies, too, almost all the scales are of highly specialized form, the forewings, especially, being covered from base to apex and from costa to inner margin with broad, flat, stiff scales.

Family **Megalopygidæ** (figs. 10 and 17).—This family, defined by Berg, is represented in North America by but one genus, *Megalopyge* Hübn. (*Lagoa* Harr.), and there are but two more extra-American genera, viz., *Ochrosoma* H-S., and *Carama* Walk. There are but three North American species of *Megalopyge*. The limited number of forms in this family is regrettable because of the exceeding interest which attaches to the scale-covering of the wings. The covering shows less specialization, probably, than is shown in any other lepidopterous family, even the most generalized representatives of other groups exceeding these forms in scale-specialization.

The wings of *Megalopyge crispata* present a covering which has been described as "more or less wooly." It consists of a mass of long, curling, fingered scale-hairs usually slightly palmated at the base of the fingers. Lying more closely appressed to the wing-membrane, beneath the mass of long, wavy scale-hairs, and especially abundant in the limbal area of the wing, are shorter and broader scales (see 6, fig. 10). The line of specialization from long, single-pointed scale-hair to specialized scale has been described on page 58, and is plainly shown in fig. 10, a series of scale-forms taken from a single forewing of *Megalopyge crispata*.

A slight but evident advance in scale condition is shown by an exotic species of this genus.* The scales reach a more specialized condition as shown in fig. 17, a series of scales taken from one forewing of this specimen. The specialized scale, number 8 in fig. 17, measures from tip of pedicel to tip of middle finger or

* This specimen, in the Cornell University collection, is not specifically determined.

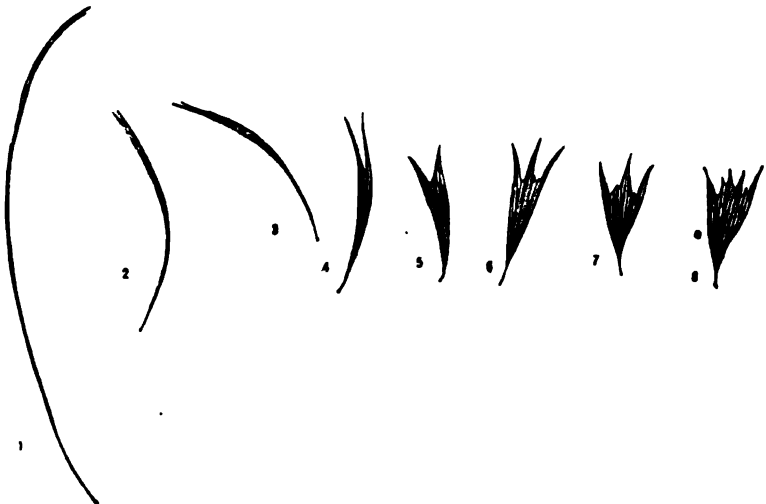



Fig. 17.
Scales from forewing of *Megalopyge* sp.

point, .208 mm.; its width from tip to tip of the two lateral fingers is .104 mm.

Family **Psychidæ** (figs. 1-11, Plate X). This family, as recently revised, comprises five North American genera, viz: *Psyche*, *Pseudopsyche*, *Platocœticus*, *Thyridopteryx* and *Oiketicus*. The genera *Lacosoma* and *Perophora*, included in this family in Smith's List,* are far removed, by venation, from this family. These five genera include but 10 North American species, the forms being but a remnant of what was once probably a considerable group. The Psychids are winged only in the male sex, the wingless female remaining in the sack which it inhabited as a larva.

I have been able to examine the wing-covering in four of the five North American genera, and the correspondence in scale specialization is obvious. The wings are sparsely scaled (in *Thyridopteryx* the scales are disappearing, the wings being mostly clear and unscaled), and there is little arrangement of the scales into rows. The specialized scales in the family are small, narrow, strongly pigmented, usually with two short points (as in *Thyridopteryx* and *Pseudopsyche*), sometimes with three short teeth (as in *Pseudopsyche*) or with one point (as in *Psyche* and *Oiketicus*). The line of specialization is as follows: The hair-form shortens, widens, and divides at the tip into two very short points, which persist or disappear during the continued shortening and widening of the scale. The points are acute, and never more than one-fifth the length of the whole scale. The striæ average about .002 mm. apart.

*Smith, John B., List of Lepidoptera of Boreal America, 1891, Philadelphia.

In *Thyridopteryx ephemeræformis* the wings, mostly clear, bear scales along the costa of the forewing of as high specialization as are to be found in the family (see figs. 6-7, Plate X). They are most abundant in the region about ¼ the length of the wing from the apex. The anal area is thinly scaled; here some hair-forms are present. In the hindwing, scales and scale-hairs are found in the costal area, in the rather large anal area, and along the outer margin and the veinlets of the median and cubital series. A typical specialized scale from the forewing was .128 mm. long and .030 mm. wide at widest portion.

In *Psyche confederata* the wings are sparsely scaled with specialized scales (see fig. 10, Plate X), and on the limbal area of the forewings a slight degree of arrangement into lines is to be noted. The characteristic one-pointed scale is thick, with convex upper and lower surfaces. A typical scale from the limbal area of the forewing was .040 mm. wide at widest portion, and .128 mm. long, the striæ being .0018 mm. apart.

*Pseudopsyche* is much like *Psyche* as regards wing-covering, but the characteristic specialized scale bears two short acute teeth or points (see figs. 8 and 9, Plate X), and the scales are slightly more numerous, this giving the wings a darker shade than those of *Psyche* have. The same degree of arrangement as on *Psyche* is apparent near the outer margin of the forewings. A typical scale was .096 mm. long, .016 mm. wide, and the striæ were .0023 apart.

In *Oiketicus abbottii* the characteristic specialized scale is obovate with rather obtusely pointed, rounded single point at apex (see fig. 11, Plate X). Among some scales taken from the base of the wing were a few two- to three-pointed ones, the points being short and usually rather blunt (sometimes acute). All the scales are strongly pigmented and thick, with convex surfaces. A typical scale was .2 mm. long and .064 mm. wide.

Family **Cossidæ** (fig. 11, p. 65). This family includes but five North American genera, comprising but few species. The scale-covering is usually sparse; the scales are not well arranged in rows, and are conspicuously assurgent, i. e., not closely appressed to the wing-membrane.

In *Prionoxystus robiniæ* the male has very small hindwings. The basal area of the hindwing is covered with blackish scale-hairs; the anal area with yellowish scale-hairs and flat scales; the limb of the wing is yellowish covered with specialized assurgent scales; the costal area is covered with blackish specialized scales. The forewings are pretty evenly covered with flat, broad, specialized scales, which are especially assurgent on the basal area. The line of specialization

is as follows: The hair-form widens, acquiring convex lateral margins; there is then a shortening and widening of the scale, without "fingering," and with the greatest breadth at or near the outer margin, until a broad, short sub-pyramidal or sub-orbicular form is attained, with outer margin rounding truncate or sinuous. This mode of development holds for *Cossus*, *Hypopta* and *Zeuzera* (*Cossula* I have not examined). In *Cossus* the scales may show a slight emargination in the middle of the outer margin thus making two short, rounded, blunt lobes, or there may be two emarginations forming three lobes. But these lobes are caused by an extra prominence of the sinuosity, and appear only in specialized scales and not on the generalized scales. A typical specialized scale from the forewing of *Prionoxystus robiniæ* was .152 mm. long and .120 mm. wide at widest part.

Family **Parasidæ** (see figs. 19–29, Plate X). This family is the largest among the generalized Frenatæ, 13 North American genera being included in it. I have examined specimens representing six of these genera, viz., *Euclea*, *Empretia*, *Parasa*, *Isa*, *Tortricidia* and *Limacodes*. The typical specialized scale is broad and large with six or eight short, acicular points on the outer margin (see 24, 25 and 27, Plate X). The scales contain much less pigment than do those in the other families of the "generalized Frenatæ." They appear comparatively clear and transparent. The small amount of pigment granules present is usually aggregated along the outer margin, in the teeth, along the lateral margins and often along a median longitudinal line.

The line of specialization, as shown in *Euclea cippus*, shows a widening, especially distad, of the hair-form, the appearance of two and then several short, pointed teeth, accompanied by continuous shortening and broadening of the scale blade. The widest portion of the scale is always at the base of the teeth so that there is a gradual tapering of the scale blade to the pedicel. Often in scales, probably not of the most specialized type, the lateral margins are sub-parallel for some distance behind the outer margin.

In the scale of the hindwing of *Euclea cippus* the outer margin or apex of the scale is not toothed but single-pointed (see 28 and 29, Plate X). A typical scale from the base of the forewing of *cippus* was .224 mm. long and .112 mm. wide, and the striæ were .0014 mm. apart. This scale had 7 teeth; the scales of the disc and limb of the wing are hardly as large.

In *Tortricidia testacea* the scales average smaller than in *Euclea*, and are proportionally narrower.

The specialized scales in the six genera examined by me were very uniform in shape and size. They suggest slightly the special-

ized scales of the Lasiocampidæ (see fig. 12), but the teeth of the Parasid scales are never long, as they always are in the Lasiocampid family.

Family **Pyromorphidæ** (figs. 12-18, Plate X). This small family comprises but four North American genera, viz., *Acoloiths*, *Triprocris*, *Pyromorpha* and *Harrisina*. The species are few, the total number of North American forms being but twelve. They are all small moths with smoky black wings. The wings are sparsely scaled, those of *Harrisina* being less thinly scaled than the others. There is little or no evidence of arrangement of the scales into rows, the covering being obviously little specialized. The line of specialization of the scales is well shown in any one of the four genera, the scales throughout the family showing a striking similarity both in generalized and specialized forms. The line of development is as follows: A widening of the hair-form, a splitting of the distal end into two fingers, and a gradual widening and shortening of the scale-blade, resulting finally in a rather narrow, two-pointed, small scale. The points may be rather long and sub-acute, as in the typical specialized scale of *Triprocris* (see fig. 14, Plate X), or short and acutely- or bluntly-angulated as in *Harrisina* and *Pyromorpha* (see figs. 16 and 18, Plate X). In *Acoloithus* the fingers or points are very short and usually bluntly angulated (see fig. 17, Plate X). The scales of *Acoloithus* are smaller than those of the other genera. A typical scale of *Acoloithus falsarius*, forewing, measured .068 mm. in length and .02 mm. in width. A scale of *Harrisina coracina* was .112 mm. long, .024 mm. wide, and its striæ were .0017 apart. A scale of *Triprocris martenii* was .120 mm. long and .024 mm. wide.

The four genera show some variation in degree of specialization of wing-covering, *Triprocris* possessing the seemingly most generalized covering, then coming *Pyromorpha*, *Harrisina*, and *Acoloithus* in order named.

### THE SPECIALIZED FRENATÆ.

Among the large families of the "specialized Frenatæ" the study of the wing-covering becomes more difficult. Certain general conditions are noticeable, conspicuous among them being the great abundance and the highly-specialized arrangement of the scales among the butterflies. A perfection of even, strict arrangement of the scales into parallel rows and into overlapping tiers in each row is arrived at. To compare the general appearance of an irregular arrangement (or lack of arrangement) and a regular arrangement, figures 33 and 34 are introduced into Plate X.

Limitations of time and space prevent me from considering in this paper the scale-conditions in the various families of the "specialized

Frenatæ." I have, in fact, been able to study so far only a few families, some few notes on one of which, the Lasiocampidæ, are presented herewith. It is my hope to continue the study of these scale-conditions in the light of their taxonomic value. In this study it will be desirable to endeavor to recognize the different lines of development followed by the scales of the various families, and the different degrees of scale-specialization shown by the various members of each family. I believe some characters of interest and value can be derived from such a study.

Family **Lasiocampidæ** (fig. 12, p. 66; and figs 30-32, Plate X). The family includes, according to Comstock, the North American genera *Clisocampa*, *Artace*, *Tolype*, *Heteropacha*, *Gastropacha*, *Gloveria*, *Thauma* and *Quadrina*. I have been able to examine specimens of all these genera, including the rare *Quadrina*, the only known specimen of which (*Q. diazoma*), taken by Prof. F. H. Snow, is now in the collection of the University of Kansas. The typical specialized scale in this family is especially characterized by its many long, acute fingers or teeth (see figs. 30, 31, 32, Plate X). These fingers vary in length, compared with the whole length of the scale (from tip of pedicel to tip of middle finger) from one-third of this length, or even less as in *Clisocampa*, to two-thirds or more as in *Tolype*. The scales of *Clisocampa* depart most widely from the typical scale of the family in the shortness and small number of the fingers, three being the common number of fingers.

The line of development has been described for *Gloveria arizonensis* (see p. 65), and is illustrated for this species in figure 12. The arrangement of the scales in rows is fairly apparent but there is no such regularity and tiered arrangement as presented by the more specialized Frenatæ (see figs. 33 and 34, Plate X).

I desire to thank Prof. John Henry Comstock, Anna Botsford Comstock and Mary Wellman for favors rendered in connection with the preparation of this paper.

NOTE.--I am acquainted with the papers on Lepidoptera scales by Kettelhoit (Ueber die Schuppen der Schmetterlingsfluegel, Colmar, 1881, first printed in Latin as a dissertation in 1859); and Schneider (Die Schuppen an den verschiedenen Fluegel- and Koerpertellen der Lepidopteren. Zeitschr. f. d. ges. Naturw. Bd. LI. 1878). Kettelhoit's paper is of special interest.

# A Chemical Examination of the Waters of the Kaw River and Its Tributaries.

BY E. H. S. BAILEY AND E. C. FRANKLIN.

An examination of the map of the state of Kansas reveals the fact that the Kaw or Kansas river drains nearly one-half of the state. It is estimated that the drainage basin of this river is 34,684 square miles or about 44 per cent. of the total area of the state, and that 38 per cent. of the whole population of the state resides in this valley. On account of these considerations, then, the character of the water of this river system is of great importance. This investigation has been taken up at the request of the American Debenture Company, who are interested in supplying several of the towns in the valley with water, and we here tender to them our thanks for their kind permission to use the facts reported below, in the interest of science and for the general good.

Looking again at the map of the state it will be noticed that the Kaw river is not simply one long stream with several insignificant branches, but it is the name applied to the aggregation of a number of large streams. Properly speaking we might consider that the Kaw was formed by the confluence of the Saline and the Smoky Hill at New Cambria, a town a few miles below Salina. This is evident when it is noticed that the streams are of about the same size and drain a similar area. The name Smoky Hill has however been given to the stream till it receives the waters of the larger Republican river at Junction City; and with this understanding the Saline is considered a branch of the Smoky Hill.

About ten miles below New Cambria, before the Smoky Hill unites with the Republican, it receives a large accession by the waters of the Solomon, flowing in also from the north. These four streams drain considerably more than the northwestern quarter of the state besides a large area in Nebraska. The head waters of the Smoky Hill are in the extreme eastern part of Colorado, while the Saline and the Solomon, though flowing nearly parallel to this, rise in the extreme western part of the state, and a large area on the north border is drained by streams which run northeast into the Republican in Nebraska, and

then this stream bends abruptly to the southeast and flows through a broad valley in Kansas till it meets the Smoky Hill at Junction City.

About thirty miles below this point another large stream, the Blue river, flows in from the north. This stream, besides running through several counties in Kansas, drains quite a large area in Nebraska. Farther east the basin of the Kaw river is narrower. It receives the waters of several small streams, the largest of these being the Delaware which flows in nearly opposite Lecompton, and the Wakarusa which flows in at Eudora. This stream flows through a valley nearly parallel to the Kaw, and is the largest that enters from the south. The Stranger, flowing in at Linwood, is a stream of considerable importance. It will be noticed that nearly all the waters flowing into the Kaw are from the north. South of this stream the state is drained through its western portion by the Arkansas, and further east by several streams flowing towards the southeast.

Most of the analyses of the waters of the streams that go to make up the Kaw were made in the winter of 1892-3, though the waters of a few of the smaller tributary streams were analyzed the succeeding winter. We have made a careful examination of the waters of the following streams: Smoky Hill river, sample taken below Salina; Saline river, sample taken above New Cambria; Solomon river, sample taken above the city of Solomon: Republican river, sample taken above Junction City; Blue river, sample taken above the city of Manhattan; Kaw river, sample taken above the city of Topeka; Delaware river, sample taken at Perryville; Kaw river, sample taken above the city of Lawrence; Wakarusa river, sampie taken south of Lawrence; Stranger river, sample taken at Linwood. In addition to the above a number of analyses of the Kaw river have been made at intermediate points between Topeka and Lawrence, as will be noticed below. Besides this we have examined the waters of the Kaw at Lawrence at several different seasons, and stages of the river.

Since the water of the Kaw, as delivered at the cities near its mouth, is composed of waters of such different character, as will be inferred from the diverse areas which they drain, it is of interest to know what is the character of the composite water and from what particular region the various impurities are derived. Of course the amount of water discharged by each of the tributaries must be taken into consideration as far as possible, and that has been done by an approximate determination of the flow at the winter stage when the examinations were made. For these estimates, and many other data in regard to the topography of the country, we are indebted to Col. F. A. Dockray, C. E. He estimates that "about half of the river at Lawrence (forty miles above the mouth of the stream) at the

winter stage comes from the upper tributaries, and 60 per cent. of this, or about a third of the whole river flow at Lawrence, is the water of the Republican and the Blue together." The source of the remaining water, as discharged at the mouth of the Kaw, is largely the water that is contributed by springs and by sub-surface infiltration. There is then a large stream, running beneath the surface through the Kaw valley, and to this we owe the fact that the river does not dry up entirely in its lower reaches during the dry season.

## Methods of Analysis.

The analyses were made as soon as possible after the waters were collected. This was especially true of the examination for organic matter. Great care was also exercised that the samples as delivered at the laboratory should be genuine and in no way contaminated by the bottles or containers.

The plan followed for the mineral analysis was that generally used in chemical laboratories. The method of stating the results is practically that followed by the best known writers and analysts in England.

The determination of organic carbon and nitrogen was made by the method of Frankland (Frankland's Water Analysis, and Prof. Mallet's report to the U. S. Board of Health, 1882). To those who have used it, this process is known to be laborious, but the results obtained in this case were satisfactory, as they confirmed the figures obtained by the ordinary free and albuminoid ammonia process. It is worthy of note in the consideration of this process that the methods of evaporation of the water that have been suggested, are at the best attended with difficulties, and that the process of evaporation requires so long a time as to make it very inconvenient. Wanklyn was followed in the determination of free and albuminoid ammonia. A few well known modifications of the process were made use of. For nitrates, the method used was the old one of reduction of the nitrates and nitrites to ammonia by means of the copper-zinc couple, and the subsequent distillation of the ammonia and determination by Nesslerizing (Untersuchung des Wassers, Tiemann-Gartner; also Frankland, p. 37). The method of estimation of nitrates by conversion into trinitrophenol, which is an excellent one in some cases, was not applicable here on account of the large amount of chlorides present in this water. The Crum method and the process of boiling with ferrous chloride were found to be less satisfactory, on account of the fact that there was so small a quantity of nitrites in this water, and so a correspondingly large amount of the water must be used to get accurate results.

The test for nitrites was made by the use of napthylammonium chlorid and sulfanilic acid. The characteristic pink color developed in the presence of nitrites was compared with that produced in a solution of sodium nitrite of known strength. Of course in the method above described the nitrates and nitrites were determined together, and the nitrites being determined, the nitrates were found by difference.

## Analyses.

In each case we give the mineral analysis in parts per 100,000, followed by the probable combination in which the elements occur. In some cases the sodium was calculated. In all these waters it is probable that the small quantity of iron present exists in the solution as bicarbonate. Following the mineral analysis is what is usually termed the "sanitary analysis," the organic matter being estimated both by the nitrogen and carbon found by combustion and that shown by the free and albuminoid ammonia method.*

### SMOKY HILL RIVER.

| | | | |
|---|---|---|---|
| Total solids | 101.70 | Sodium oxid, calculated | 24.56 |
| Silica and insoluble residue | 2.08 | Chlorin | 22.93 |
| Iron and Alumina oxids | 0.70 | Sulfuric anhyrid | 20.91 |
| Calcium oxid | 19.86 | Carbonic anhydrid, calculated | 12.06 |
| Magnesium oxid | 4.46 | | |

It is probable that the above constituents are combined in the following manner:

| | | | |
|---|---|---|---|
| Silica and insoluble residue | 2.08 | Magnesium carbonate, | 9.37 |
| Iron and alumina oxids | 0.70 | Sodium chlorid | 37.78 |
| Calcium sulfate | 26.25 | Sodium sulfate | 9.71 |
| Calcium carbonate | 16.16 | | |

SANITARY ANALYSIS.

| | | | |
|---|---|---|---|
| Total solids | 101.7000 | Nitrogen as nitrates and nitrites | 0.0080 |
| Organic carbon | 0.6080 | Nitrogen as nitrites | 0.0015 |
| Organic nitrogen | 0.1500 | Total combined nitrogen | 0.1613 |
| Free ammonia | 0.0040 | Chlorin | 22.9300 |
| Albuminoid ammonia | 0.0116 | | |

### SALINE RIVER.

| | | | |
|---|---|---|---|
| Total solids | 232.30 | Sodium oxid, calculated | 87.17 |
| Silica and insoluble residue | 2.44 | Chlorin | 85.85 |
| Iron and alumina oxids | 0.50 | Sulfuric anhydrid | 35.02 |
| Calcium oxid | 19.54 | Carbonic anhydrid, calculated | 24.91 |
| Magnesium oxid | 7.78 | | |

*In this and all other cases below most of the calcium and magnesium, when not in solution as sulfate, is present as bicarbonate.

These constituents are probably combined in the water, before evaporation, as follows:

| | | | |
|---|---|---|---|
| Silica and insoluble residue | 2.44 | Magnesium carbonate | 16.34 |
| Iron and alumina oxids | 0.50 | Sodium chlorid | 113.30 |
| Calcium carbonate | 34.89 | Sodium sulfate | 62.16 |

SANITARY ANALYSIS.

| | | | |
|---|---|---|---|
| Total solids | 232.3000 | Nitrogen as nitrates and nitrites | 0.0670 |
| Organic carbon | 0.6560 | Nitrogen as nitrites | 0.0001 |
| Organic nitrogen | 0.1230 | Total combined nitrogen | 0.1970 |
| Free ammonia | 0.0080 | Chlorin | 85.8500 |
| Albuminoid ammonia | 0.0510 | | |

## SOLOMON RIVER.

MINERAL ANALYSIS.

| | | | |
|---|---|---|---|
| Total solids | 110.50 | Sodium oxid, calculated | 30.42 |
| Silica and insoluble residue | 4.00 | Chlorin | 27.05 |
| Iron and alumina oxids | 0.50 | Sulfuric anhyrid | 21.46 |
| Calcium oxid | 17.86 | Carbonic anhydrid, calculated | 11.41 |
| Magnesium oxid | 3.96 | | |

It is probable that the above constituents are combined in the water in the following manner:

| | | | |
|---|---|---|---|
| Silica and insoluble residue | 4.00 | Magnesium carbonate | 8.30 |
| Iron and alumina oxids | 0.50 | Sodium chlorid | 44.57 |
| Calcium carbonate | 16.05 | Sodium sulfate | 15.54 |
| Calcium sulfate | 21.54 | | |

SANITARY ANALYSIS.

| | | | |
|---|---|---|---|
| Total solids | 110.5000 | Nitrogen as nitrates and nitrites | 0.0040 |
| Organic carbon | 0.6360 | Nitrogen as nitrites | 0.0001 |
| Organic nitrogen | 0.1600 | Total combined nitrogen | 0.1600 |
| Free ammonia | 0.0024 | Chlorin | 27 0500 |
| Albuminoid ammonia | 0.0190 | | |

## REPUBLICAN RIVER.

MINERAL ANALYSIS.

| | | | |
|---|---|---|---|
| Total solids | 55.37 | Sodium oxid, calculated | 9.65 |
| Silica and insoluble residue | 6.36 | Chlorin | 5.49 |
| Iron and alumina oxids | 0.76 | Sulfuric anhydrid | 6.26 |
| Calcium oxid | 11.98 | Carbonic anhydrid, calculated | 12.62 |
| Magnesium oxid | 2.92 | | |

These constituents are probably combined as follows:

| | | | |
|---|---|---|---|
| Silica and insoluble residue | 6.36 | Magnesium carbonate | 6.13 |
| Iron and alumina oxids | 0.76 | Sodium chlorid | 9.05 |
| Calcium carbonate | 21.89 | Sodium sulfate | 11.11 |

SANITARY ANALYSIS.

| | | | |
|---|---|---|---|
| Total solids | 55.3700 | Organic nitrogen | 0.1096 |
| Organic carbon | 0.5810 | Free ammonia | 0.0003 |

| | | | |
|---|---|---|---|
| Albuminoid ammonia | 0.0278 | Nitrogen as nitrites | 0.0005 |
| Nitrogen as nitrates and nitrites | 0.0200 | Total combined nitrogen | 0.1292 |
| | | Chlorin | 5.4900 |

## BLUE RIVER.

### MINERAL ANALYSIS.

| | | | |
|---|---|---|---|
| Total solids | 43.64 | Sodium oxid, calculated | 4.63 |
| Silica and insoluble residue | 3.74 | Chlorin | 2.82 |
| Iron and alumina oxids | 0.72 | Sulfuric anhydrid | 5.87 |
| Calcium oxid | 11.52 | Carbonic anhydrid, calculated | 11.31 |
| Magnesium oxid | 3.57 | | |

It is probable that the above constituents are combined as follows in the water:

| | | | |
|---|---|---|---|
| Silica and insoluble residue | 3.74 | Magnesium carbonate | 7.50 |
| Iron and alumina oxids | 0.72 | Sodium chlorid | 4.65 |
| Calcium sulfate | 5.30 | Sodium sulfate | 4.97 |
| Calcium carbonate | 16.73 | | |

### SANITARY ANALYSIS.

| | | | |
|---|---|---|---|
| Total solids | 43.6400 | Nitrogen as nitrates and nitrites | 0.0048 |
| Organic carbon | 0.2920 | Nitrogen as nitrites | 0.0002 |
| Organic nitrogen | 0.0870 | Total combined nitrogen | 0.0953 |
| Free ammonia | 0.0040 | Chlorin | 2.8200 |
| Albuminoid ammonia | 0.0165 | | |

## KAW RIVER, ABOVE TOPEKA.

### MINERAL ANALYSIS.

| | | | |
|---|---|---|---|
| Total solids | 77.12 | Sodium oxid, calculated | 15.72 |
| Silica and insoluble residue | 4.42 | Chlorin | 14.43 |
| Iron and alumina oxids | 0.56 | Sulfuric anhydrid | 12.10 |
| Calcium oxid | 16.08 | Carbonic anhydrid, calculated | 12.96 |
| Magnesium oxid | 4.57 | | |

It is probable that these constituents are combined as follows:

| | | | |
|---|---|---|---|
| Silica and insoluble residue | 4.42 | Magnesium carbonate | 10.05 |
| Iron and alumina oxids | 0.56 | Sodium chlorid | 23.77 |
| Calcium sulfate, | 15.26 | Sodium sulfate | 5.56 |
| Calcium carbonate | 17.50 | | |

### SANITARY ANALYSIS.

| | | | |
|---|---|---|---|
| Total solids | 77.1200 | Nitrogen as nitrates and nitrites | 0.0100 |
| Organic carbon | 0.3220 | Nitrogen as nitrites | 0.0000 |
| Organic nitrogen | 0.0540 | Total combined nitrogen | 0.0654 |
| Free ammonia | 0.0017 | Chlorin | 14.4300 |
| Albuminoid ammonia | 0.0186 | | |

## DELAWARE RIVER.*

MINERAL ANALYSIS.

| | | | |
|---|---|---|---|
| Total solids | 30.56 | Sodium oxid, calculated | 2.48 |
| Silica and insoluble residue | 1.31 | Chlorin | 2.33 |
| Iron and alumina oxids | 0.53 | Sulfuric anhydrid | 3.63 |
| Calcium oxid | 12.51 | Carbonic anhydrid, calculated | 12.02 |
| Magnesium oxid | 3.54 | | |

It is probable that the constituents are combined in the water as follows:

| | | | |
|---|---|---|---|
| Silica and insoluble residue | 1.31 | Magnesium carbonate | 7.43 |
| Iron and alumina oxids | 0.53 | Sodium chlorid | 3.86 |
| Calcium carbonate | 10.80 | Sodium sulfate | 2.96 |
| Calcium sulfate | 3.33 | | |

SANITARY ANALYSIS, PARTIAL.

| | | | |
|---|---|---|---|
| Total solids | 30.5600 | Free ammonia | trace. |
| Nitrogen as nitrates and nitrites | 0.0178 | Albuminoid ammonia | 0.0280 |
| | | Chlorin | 2.3400 |

## KAW RIVER, ABOVE LAWRENCE.

MINERAL ANALYSIS.

| | | | |
|---|---|---|---|
| Total solids | 76.16 | Sodium oxid, calculated | 16.25 |
| Silica and insoluble residue | 3.01 | Chlorin | 14.43 |
| Iron and alumina oxids | 0.48 | Sulfuric anhydrid | 11.13 |
| Calcium oxid | 15.66 | Carbonic anhydrid, calculated | 13.85 |
| Magnesium oxid | 4.40 | | |

These constituents are probably combined as follows.

| | | | |
|---|---|---|---|
| Silica and insoluble residue | 3.01 | Magnesium carbonate | 9.68 |
| Iron and alumina oxids | 0.48 | Sodium chlorid | 23.77 |
| Calcium sulfate | 10.88 | Sodium sulfate | 8.38 |
| Calcium carbonate | 19.96 | | |

SANITARY ANALYSIS.

| | | | |
|---|---|---|---|
| Total solids | 76.1600 | Nitrogen as nitrates and nitrites | 0.0100 |
| Organic carbon | 0.6000 | Nitrogen as nitrites | 0.0000 |
| Organic nitrogen | 0.0750 | Total combined nitrogen | 0.0853 |
| Free ammonia | 0.0004 | Chlorin | 14.4300 |
| Albuminoid ammonia | 0.0250 | | |

## WAKARUSA RIVER.†

MINERAL ANALYSIS.

| | | | |
|---|---|---|---|
| Total solids | 49.92 | Sodium oxid, calculated | 8.92 |
| Silica and insoluble residue | 1.48 | Chlorin | 8.45 |
| Iron and alumina oxids | 0.56 | Sulfuric anhydride | 8.27 |
| Calcium oxid | 16.88 | Carbonic anhydrid, calculated | 16.15 |
| Magnesium oxid | 2.68 | | |

*Samples collected in December, 1893. Analysis by J. E. Curry.

†Samples collected in January, 1894. Analysis by J. E. Curry.

It is probable that the constituents are combined as follows:

| | | | |
|---|---|---|---|
| Silica and insoluble residue... | 1.43 | Magnesium carbonate........ | 5.62 |
| Iron and alumina oxids...... | 0.56 | Sodium chlorid............. | 5.60 |
| Calcium carbonate........... | 30.05 | Sodium sulfate.............. | 5.68 |
| Calcium sulfate............. | 0.12 | | |

SANITARY ANALYSIS, PARTIAL.

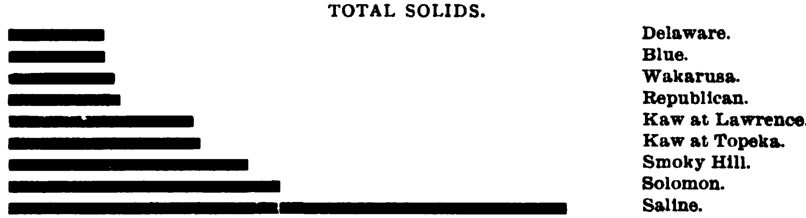
| | | | |
|---|---|---|---|
| Total solids................. | 49.9200 | Nitrates and nitrites......... | 0.0120 |
| Free ammonia............... | 0.0006 | Chlorin. ..................... | 3.4500 |
| Albuminoid ammonia........ | 0.0300 | | |

An analysis of the Stranger, made by Mr. J. G. Hall in May, 1894, showed that 100,000 parts contained 27.00 total solids, consisting essentially of calcium sulfate and calcium carbonate. The amount of sodium chlorid was small, 1.21 parts. As this stream is quite small its waters do not contribute very materially to the waters of the Kaw as delivered at its mouth; in fact it is but little larger than several other creeks that flow into the river both from the north and the south sides.

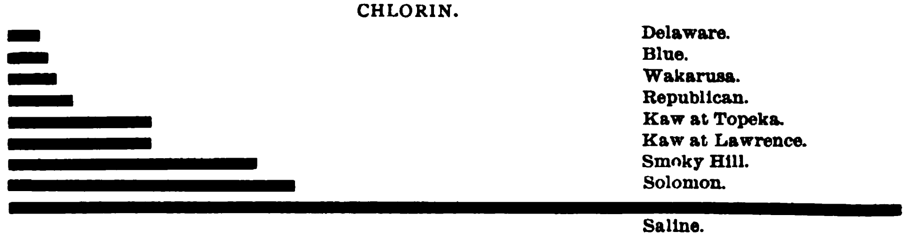
These constituents may best be compared by the graphic method. From this it can be seen at a glance what is the source of the important mineral constituents of the Kaw river.

**COMPARISON OF MINERAL CONSTITUENTS IN THE WATERS OF THE KAW VALLEY.**

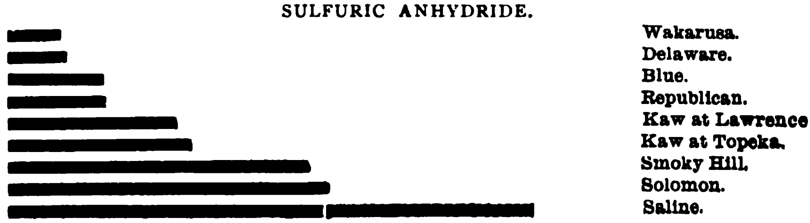
TOTAL SOLIDS.




CHLORIN.




SULFURIC ANHYDRIDE.



SODA.


The constituents that have been graphically represented above are the only ones that differ very essentially in quantity. The Blue river contains the least quantity of lime salts, and the Smoky Hill and Saline the most, but this quantity is not excessive, and is less than twice the amount contained in the purest of the series. The magnesium is also small in all the waters examined. But here again the Saline furnishes the greatest per cent.; this stream too contains more magnesia than the Smoky Hill.

By an examination of the soda plate and the sulphuric anhydride plate it will be noticed that the great "alkali region," in addition to being in the Saline valley as would be expected, is also in the Smoky Hill and Solomon valleys. There is very little difference between the water of the two latter rivers in this respect.

It will be noticed also that the "salt" of the Kaw, unless it comes from some underground source, comes from the three upper tributaries: Delaware, Blue and Republican furnishing very little of the salt found in the water at Lawrence. It is an undisputed fact that the unpolluted ground water of the Kaw valley does contain considerable mineral matter. The present supply of the city of Topeka, for instance, is obtained by means of points driven beside the river bank, and this water contains 12.78 parts of chlorin per 100,000. The water of a sixty-foot drive well in the bottom north of Lawrence water works, contained 23.74 parts of chlorin.

Referring to that part of the examination that may be more properly called the "sanitary" portion, it is interesting to note that the waters of the three upper tributaries contain much larger quantities of "total combined nitrogen" than those of the lower tributaries, and even of the Kaw itself. The river seems to have purified itself from the organic matter in the course of a hundred miles or so; and we see that the Kaw at Topeka is much better in quality than many of the tributaries that go to make it up. This may be due to any or all of the circumstances: dilution, sedimentation, and oxidation. Much of the organic matter that appears as albuminoid ammonia was shown, by the slowness with which it distilled off, to be of vegetable origin. This would tend to settle at the bottom of a slowly-flowing current.

An interesting series of experiments was also made on a reach of the river about thirty-two miles in length; that between Topeka and Lawrence. This was done in April, 1893. The results were as follows:—

| | CHLORIN. | FREE AMMONIA. | ALBUMINOID AMMONIA. |
|---|---|---|---|
| Above Topeka | 10.73 | .0008 | .0132 |
| At Topeka, below bridge | 10.73 | .0008 | .0132 |
| At Tecumseh, 5 miles | 10.50 | .0018 | .0130 |
| At Lecompton, 12 miles further | 11.29 | .0005 | .0138 |
| At Lawrence, pumping house | 10.98 | .0028 | .0134 |

At the *winter stage* of the river the examination showed the following:—

| | FREE AMMONIA. | ALBUMINOID AMMONIA. |
|---|---|---|
| Above Topeka | .0017 | .0186 |
| At Big Bend | .0010 | .0132 |
| At Lawrence, 4 miles above dam | .0005 | .0170 |
| At Lawrence Water Works | .0004 | .0250 |

In this case it can be seen that there is a gradual purification of the river, after it has received the sewage of the city of Topeka, and that suddenly the albuminoid ammonia in one case and the free ammonia in the other rise very much in quantity. This is not an accidental result, but has been confirmed by numerous analyses. The large increase of albuminoid and free ammonia is accounted for by a microscopic examination of the water, in which it is revealed that there is a growth of diatoms in the slack water above the dam. These are not found in any quantity above the point three miles up the stream, where one of the samples was taken. The water is by no means quiet for three miles above the dam, but the current is impeded just enough, and the stream is deepened, so that these lower forms of life appear.

It is not difficult to trace the organic material of the upper tributaries of the Kaw, and indeed of the whole system, to its source. Investigation shows that there are numerous cattle pens and slaughter houses on the banks, and that in the small towns much of the organic refuse of the dwellings finally finds its way into the river. Hog wallows are very numerous also, and a great deal of this accumulated filth is flushed into the rivers at high water. To this may be added the sewage of the cities, but this is really small in comparison to the total flow of water.

In this connection it is important to notice that in this region the determination of chlorin is utterly valueless as an index of the purity or the impurity of a water supply. As an illustration of the effect of sewage, an examination was made of the Topeka sewage itself, and it was found to contain only 16.46 parts of chlorin per 100,000, or only

about two parts more of chlorin than the city water supply. The normal amount of chlorin is so large that the slight increase that might come from added sewage, would scarcely be noticed. At best the only thing that can be done is to find out about what is the normal amount in each particular water, and then by frequent analyses, a large increase might be noticed and would cause the water to be regarded as suspicious.

The organic matter of these streams is large, as is denoted by the free and albuminoid ammonia tests, and by the organic carbon and organic nitrogen tests. The rich prairie soil of these regions is continually giving up to the water that flows through and over it, this organic material. It will continue to do this till the soil becomes impoverished, and till artificial fertilizers are a necessity. On this account the standards that have been adopted in England, and to some extent those that are adopted in the northern and eastern states, where the soil is so entirely different in character, cannot be applied here. If they are too rigidly applied, all the waters of running streams, and all the lake waters are excluded as sources of domestic supply. Not only is this true, but the waters of many wells yield a surprisingly large amount of free ammonia. This is particularly true, as has been noticed by others also, in the waters of wells that are sunk in the bottoms, and that contain much iron as an impurity. Waters of this class have been encountered all through the lower Kaw valley. They contain so much iron, in a ferrous state, that when they are exposed to the action of the air the oxidation and the escape of carbonic acid allows the iron to be precipitated and a very unsightly water is the result. Any one not familiar with this class of waters, and accustomed to guage all waters by the old standards would condemn them utterly as contaminated; yet there is not, in most instances, the least opportunity for their pollution by sewage, or from any organic matter other than that which normally belongs to the soil.

It will be noticed that the nitrogen is mostly present in the least objectionable forms, namely, as nitrates and as albuminoid ammonia. Neither of these is considered as denoting *recent* contamination.

That the water of these wells is entirely of a different character from that of the adjacent river is easily proven. If we take the amount of chlorin in each as an index, and this has been found to be the best element to use in the comparison, we see a marked difference in the waters. The river water contained 9.9 parts of chlorin per 100,000, while a well on the bank at the same time contained only 3.0 parts. The river water contained only a trace of iron, while the well water contained 3.0 parts of ferric oxide per 100,000.

From a comparison of the water of the Kaw river and its tributaries

with that of other streams that flow through similar regions, with that of the Great Lakes and rivers, it is evident that they all belong to the same general class. Many of these waters must, for the present, be used as sources of city supply. They are capable of much improvement by sedimentation and by filtration, as this removes much of the suspended silt and organic material. These waters have been in use, for a series of years, with impunity, notwithstanding the large amount of organic material that they contain, and it has not yet been demonstrated that this use is detrimental to health.

## PLATE I.

Figs. 1-3. *Cimoliosaurus* sp.; 1, cervical vertebra, anterior view; 2, same vertebra, side view; 3, humerus (femur?).

Fig. 4. Femur of crocodile?

Fig. 5. Vertebra of crocodile.

All the figures are two-thirds natural size.

Fig. 1.

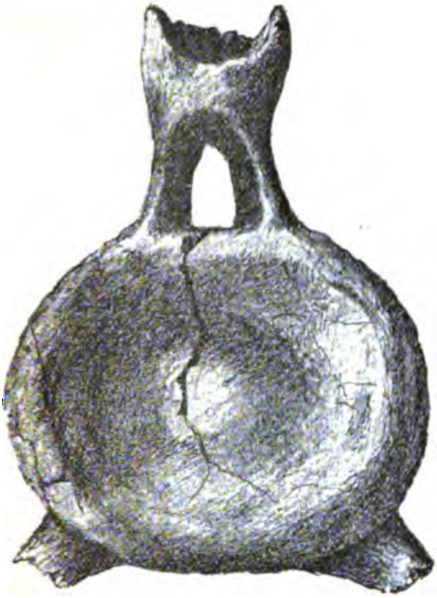


Fig. 2.

Fig. 3.

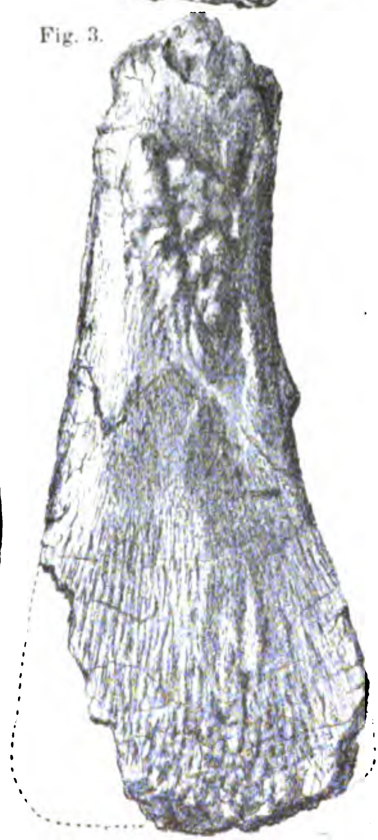


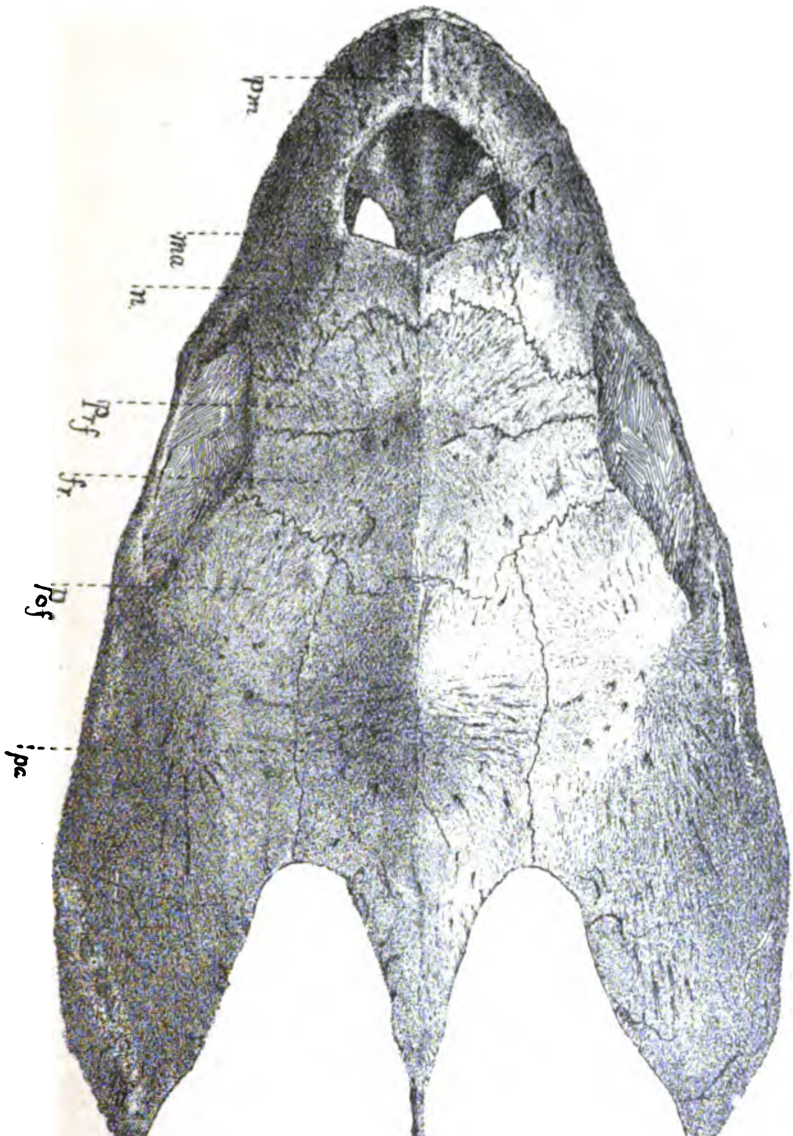
Fig. 4.

Fig 5.

Mary H. Wellman, from nature.

## PLATE II.

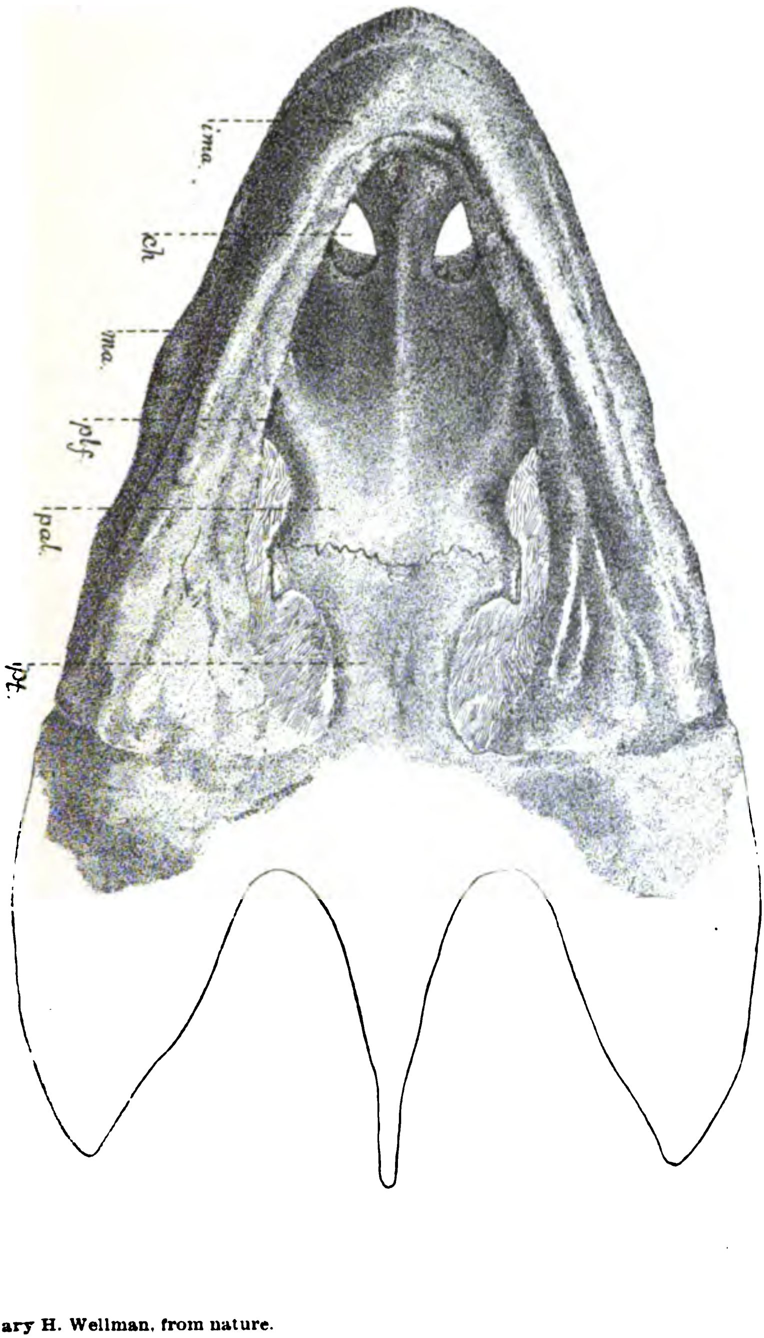
Skull of *Desmatochelys Lowii* Williston, two-thirds natural size; *pm*, premaxillary; *ma*, maxillary; *n*, nasal; *pfr*, prefrontal; *pa*, parietal; *fr*, frontal; *pof*, postfrontal.




Mary H. Wellman, from nature.

## PLATE III.

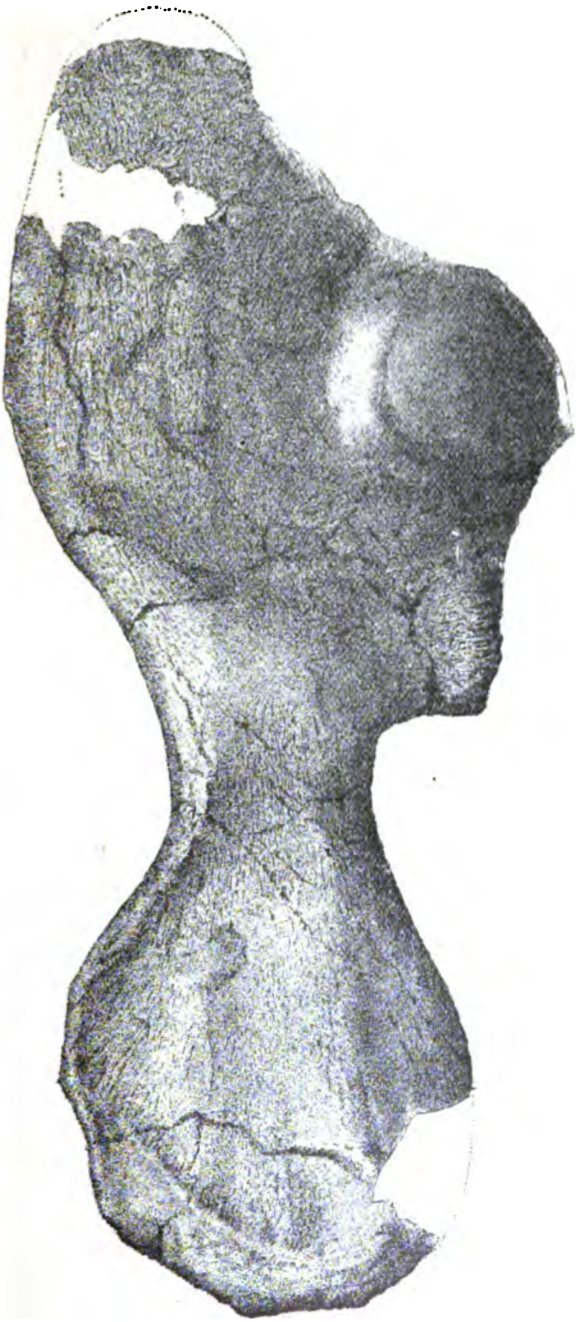
Skull of *Desmatochelys Lowii* Williston, palatal aspect, two-thirds natural size; *ima*, mandible; *ch*, choana; *ma*, maxillary; *plf*, palatine foramen; *pal*, palatine; *pt*, pterygoid.




Mary H. Wellman, from nature.

## PLATE IV.

Right humerus of *Desmatochelys Lowii* Williston, two-thirds natural size.



Mary H. Wellman, from nature.

## PLATE V.

Fig. 1. *Desmatochelys Lowii* Williston, coracoid.
Fig. 2. Radius and ulna (*a*) of same.
Fig. 3. Scapula-precoracoid of same.
All the figures are two-thirds natural size.

Fig. 1.

Fig. 2.

Fig. 3.

Mary H. Wellman. from nature.

## PLATE VI.

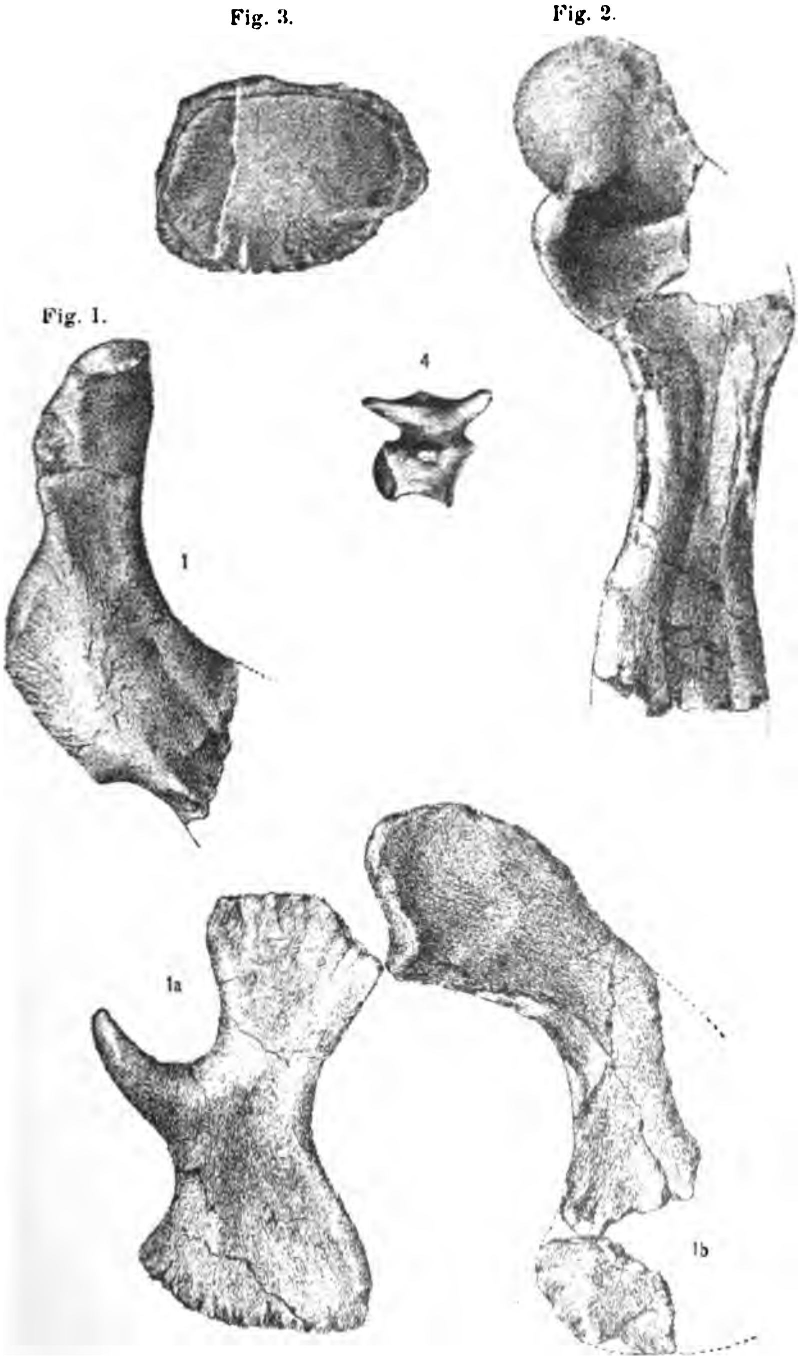
Fig. 1. *Desmatochelys Lowii* Williston, right pelvic bones, inner side; 1, ilium; 1*a*, ischium; 1*b*, pubis.

Fig. 2. Femur of same.

Fig. 3. Carpal bone of same.

Fig. 4. Caudal vertebra of same.

All the figures are two-thirds natural size.




Mary H. Wellman. from nature.

PLATYGONUS LEPTORHINUS.
One-eighth natural size.

## PLATE IX.

Fig. 1. Portion of the forewing of *Neuronia postica*, showing scale-hairs and fine, fixed hairs. (Magnified.)

Fig. 2. Portion of the forewing of *Panorpa* sp., showing scale-hairs and fine, fixed hairs. (Magnified.)

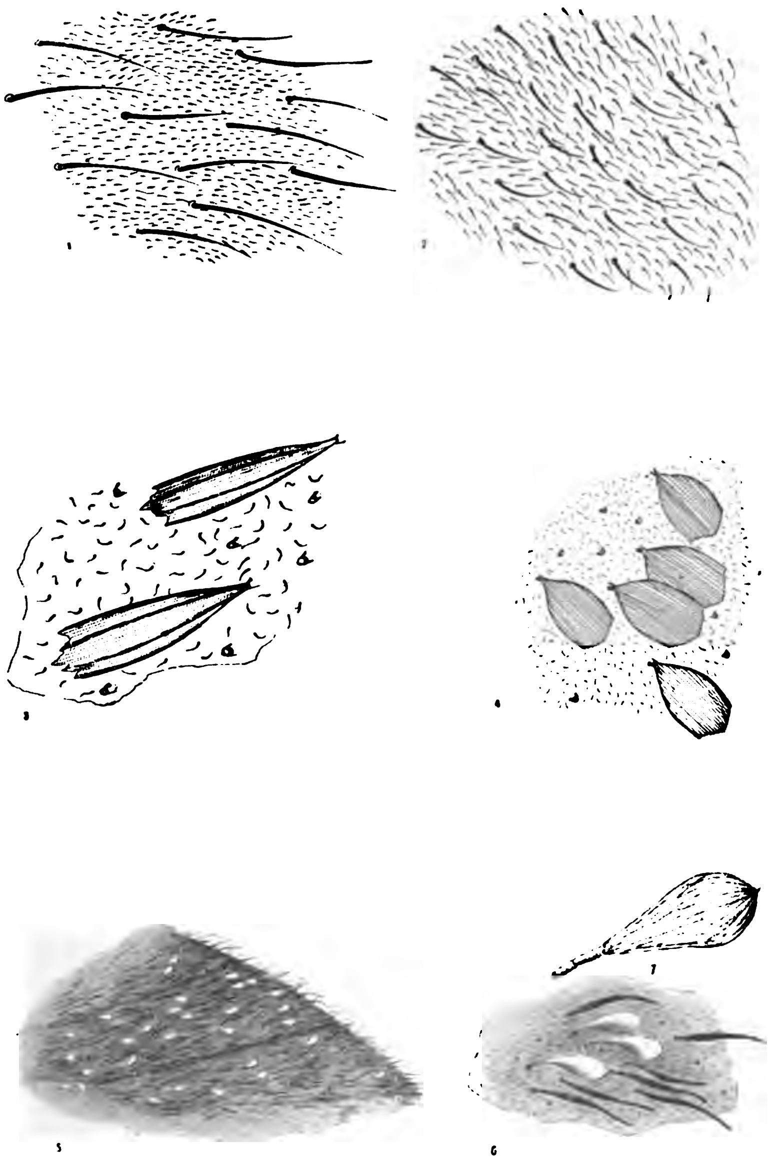
Fig. 3. Portion of the forewing of *Hepialus sylvinus*, showing scales and fine, fixed hairs. (Magnified.)

Fig. 4. Portion of the forewing of *Micropteryx unimaculella*, showing scales and fine, fixed hairs. (Magnified.)

Fig. 5. Portion of limb of forewing of *Mystacides punctata*, showing wing-covering including scattered white androconia-like scales. (Magnified.)

Fig. 6. Portion of same still more magnified.

Fig. 7. Single white androconia-like scale of *Mystacides punctata*, greatly magnified.




Mary H. Wellman

## PLATE X.

Figs. 1-7. Scales of *Thyridopteryx ephemeræformis*. (Magnified.)

Figs. 8-9. Scales of *Pseudopsyche exigua*. (Magnified.)

Fig. 10. Scale of *Psyche confederata*. (Magnified.)

Fig. 11. Scale of *Oiketicus abbottii*. (Magnified.)

Figs. 12-14. Scales of *Triprocris martenii*. (Magnified.)

Figs. 15-16. Scales of *Harrisina coracina*. (Magnified.)

Fig. 17. Scale of *Acoloithus falsarius*. (Magnified.)

Fig. 18. Scale of *Pyromorpha dimidiata*. (Magnified.)

Figs. 19-24. Scales of *Euclea cippus*. (Magnified.)

Figs. 25-26. Scales of *Parasa chloris*. (Magnified.)

Fig. 27. Scale of *Empretia stimulea*. (Magnified.)

Figs. 28-29. Scales from hindwing of *Euclea cippus*. (Magnified.)

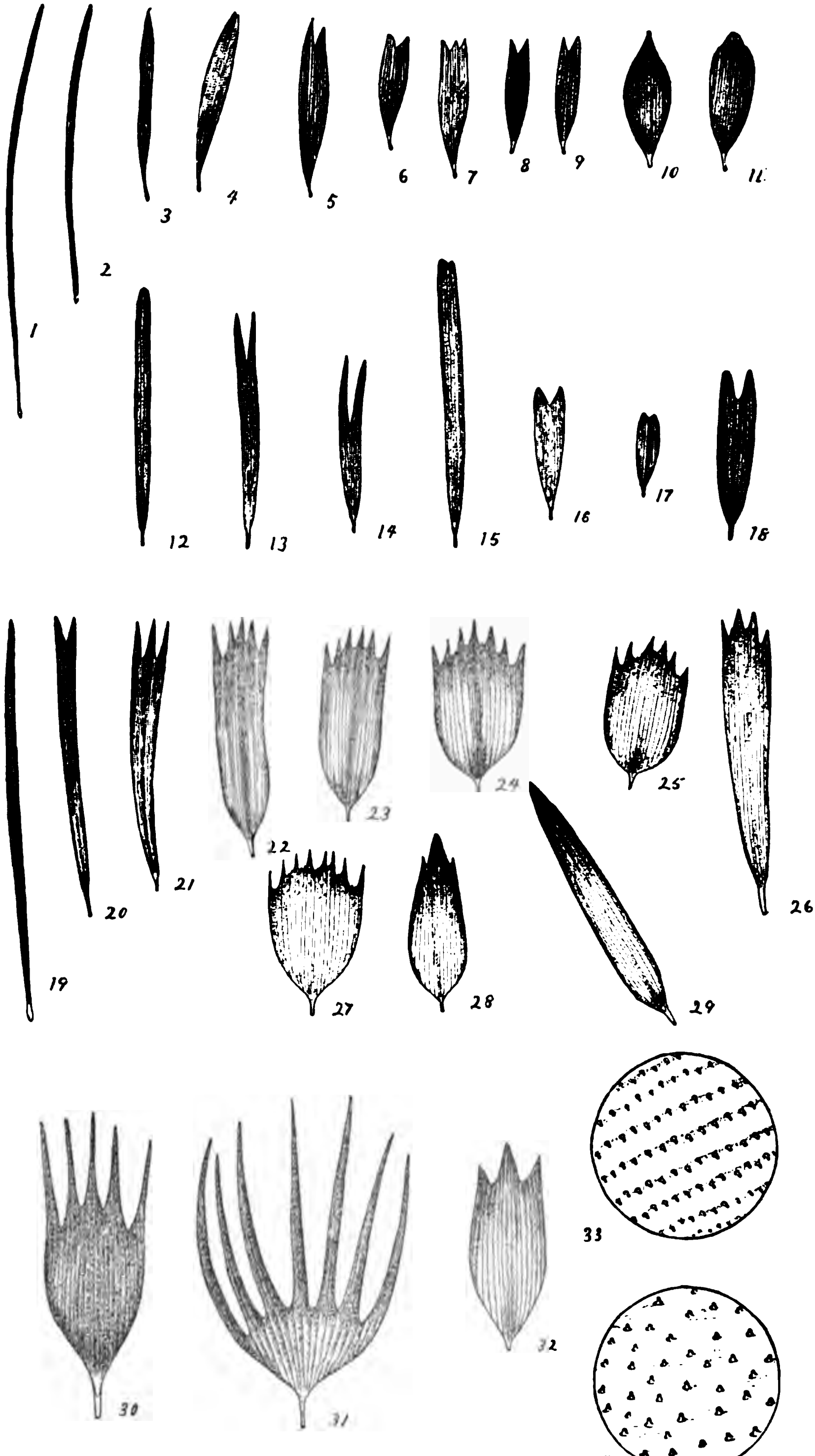
Fig. 30. Scale of *Gastropacha americana*. (Magnified.)

Fig. 31. Scale of *Tolype velleda*. (Magnified.)

Fig. 32. Scale of *Clisocampa disstria*. (Magnified.)

Fig. 33. Portion of wing of *Papilio troilus*, showing regular arrangement of insertion cups. (Magnified.)

Fig. 34. Portion of wing of *Gastropacha americana*, showing irregular arrangement of insertion cups. (Magnified.)




Mary H. Wellman and V. L. Kellogg

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# On the Hessian, Jacobian, Steinerian, Etc. in Geometry of One Dimension.

BY HENRY B. NEWSON.

Analytic Geometry of One Dimension, or Linear Analytic Geometry as it is sometimes called, is only another name for the geometric interpretation of the Theory of Binary Algebraic Forms by means of a group of points on a line. Many mathematicians have called attention to this subject as an independent branch of geometry, but few have developed it to any considerable extent. Cayley's sixth Memoir on Quantics deserves mention as one of the early papers bearing on the subject. The second chapter of Clebsch's *Theorie der Binaeren Algebraeischen Formen* is devoted to the geometric interpretation of binary forms, and the results are freely stated in a geometric form throughout the book. Clebsch-Lindemann's *Vorlesungen ueber Geometrie*, Vol. I, Kap. III, carries the development still farther, but yet leaves it very incomplete.

Throughout the work of Clebsch the algebraic spirit predominates and the geometric theory is a secondary matter. In the present paper the geometric conception is kept in the foreground and the algebraic operations are employed only as a means for developing that conception. In the following pages I have collected and restated in a geometric form some well-known theorems, and then proceeded to develope (somewhat after the manner of Salmon's Higher Plane Curves) a brief chapter in linear geometry. I have even stated some of the results as nearly as possible in Salmon's language in order to make clearer the analogy between the theorems in one and two dimensions. A sufficient account of the theory of poles and polars of binary forms, so freely used in the following pages, is to be found in Clebsch-Lindemann's *Vorlesungen*, etc., Vol. I, p. 203.

Let $U=0$ be a homogenous equation of the $n$th degree, which represents a group of $n$ points on a line. This group will be called simply an $n$ic. We know from the theory of poles and polars of binary forms that the polar with respect to U of any point $(x_1, y_1)$ on the line consists of a group of $(n-1)$ points. Generally these $(n-1)$ points are distinct and separate; but it may happen that for certain positions of $(x_1, y_1)$ some two of these $(n-1)$ points will coincide. We then say that the polar of $(x_1, y_1)$ has a double point. It is easy to find the equation of the locus* of these double points on all the first polars of U. For the first polar with respect to U of the point $(x_1, y_1)$ is given by the *polarizing operator* $\left(x_1\frac{d}{dx}+y_1\frac{d}{dy}\right)U=0$. (The term *polarizing operator* is due, I believe, to Klein. The operator $\left(x_1\frac{d}{dx}+y_1\frac{d}{dy}\right)$ is represented by $P_1$, so that the successive polars of $(x_1, y_1)$ with respect to U are written $(P_1)U$, $(P_1)^2U, \ldots (P_1)^rU$. In like manner the $(n-1)$th, $(n-2)$th... etc., polars of $(x_1, y_1)$ with respect to U, viz: those of degrees 1, 2, 3, etc., are written $(P)U_1$, $(P)^2U_1, \ldots (P)^rU_1$.) If this polar has a double point D, then the point D will belong to each of the groups represented by the x and y derivatives of $(P_1)U$. Consequently,

$$x_1\frac{d^2U}{dx^2}+y_1\frac{d^2U}{dxdy}=0.$$

$$x_1\frac{d^2U}{dxdy}+y_1\frac{d^2U}{dy^2}=0.$$

are simultaneous equations and their resultant vanishes.

Hence

$$\begin{vmatrix} \frac{d^2U}{dx^2} & \frac{d^2U}{dxdy} \\ \frac{d^2U}{dydx} & \frac{d^2U}{dy^2} \end{vmatrix} = 0.$$

This expression written for brevity $(H)U$ is called the Hessian of U. If this algebraic expression expression be taken as the definition of the Hessian of a quantic U, the above development enables us to state the following geometric property of the Hessian:

*THEOREM I.—The Hessian of a quantic U is the locus of the double points on all first polars of U.*

But the Hessian of U has another important geometric property, which we proceed to develope. The polar quadratic $(P)^2U_1$ of the point $(x_1, y_1)$ is given by the equation,

$$x^2\frac{d^2U_1}{dx_1^2}+2xy\frac{d^2U_1}{dx_1dy_1}+y^2\frac{d^2U_1}{dy_1^2}=0.$$

* This use of the word locus is convenient but perhaps not justifiable.

If this quadratic consists of coincident points, its discriminants must vanish. Therefore

$$\begin{vmatrix} \frac{d^2U_1}{dx_1^2} & \frac{d^2U_1}{dx_1dy_1} \\ \frac{d^2U_1}{dx_1dy_1} & \frac{d^2U_1}{dy_1^2} \end{vmatrix} = 0.$$

But if the point $(x_1, y_1)$ be taken as a variable point, this last expression $(H)U_1$ is no other than the Hessian of U. We are therefore able to state the following:

*THEOREM II.—The Hessian of a quantic U is the locus of all points whose polar quadratics with respect to U consist of double points.*

(For the analogous theorem in geometry of two dimensions, see Salmon's Higher Plane Curves, Art. 70).

It is plain that if U be a quantic of degree $n$, the Hessian of U is of degree $2(n-2)$; therefore the Hessian of U represents a group of $2(n-2)$ points.

Closely associated with the Hessian of a quantic U is another group of points, which from its analogous curve in two dimensional geometry, I have ventured to call the Steinerian of U.

*DEFINITION.—The Steinerian of U is the locus of all points whose first polars with respect to U have a double point; these double points of course constitute the Hessian.*

From this definition of the Steinerian it follows that the Steinerian must be of the same degree as the Hessian, viz; of the degree $2(n-2)$. The equation of the Steinerian of U is found by the following process: The equation of the first polar of $(x_1, y_1)$ with respect to U is $(P_1)U = 0$. If this first polar have a double point, its discriminant vanishes and $(x_1, y_1)$ is a point on the Steinerian. Hence equating to zero the discriminant of $(P_1)U$, we obtain an equation in x and y of the degree $2(n-2)$ which is the equation of the Steinerian.

It was shown above in Theorem II that the Hessian is the locus of all points whose polar quadratics with respect to U consist of double points. We wish now to find the equation of the locus of these double points. The equation of the polar quadratic of $(x_1, y_1)$ is

$$(P)^2U_1 = x^2\frac{d^2U_1}{dx_1^2} + 2xy\frac{d^2U_1}{dx_1dy_1} + y^2\frac{d^2U_1}{dy_1^2} = 0.$$

The condition that this should consist of coincident points is the the vanishing of its x and y derivatives, viz:

$$x\frac{d^2U_1}{dx_1^2} + y\frac{d^2U_1}{dx_1dy_1} = 0.$$

$$x\frac{d^2U_1}{dx_1dy_1} + y\frac{d^2U_1}{dy_1^2} = 0.$$

Eliminating $x_1$ and $y_1$ from these two equations, we have the equation of the desired locus. But this result is exactly the same as that obtained by equating to zero the discriminant of $(P_1)U$, except that x and y are replaced by $x_1$ and $y_1$. Hence the eliminant of the pair (2) gives us the Steinerian of U. This result may be formulated in the following:

*THEOREM III.—The Steinerian of U is also the locus of all points which are double points on polar quadratics of U, i. e. it is the locus of the polar quadratics of the Hessian.*

All the above results may be combined and the whole theory of the Hessian and Steinerian stated in the following general theorem.

*THEOREM IV.—If the first polar of a point A has a double point at B, then the polar quadratic of B has a double point at A and vice versa. The locus of all points B is the Hessian of U, and the locus of all points A is the Steinerian of U.*

The Steinerian may be defined in yet another way; since the polar of any point with respect to a double point coincides with that double point, and since the polar quadratics of the points of the Hessian are double points on the Steinerian, it follows that the polar points with respect to U of all points on the Hessian constitute the Steinerian. From this we see that we can obtain the equation of the Steinerian by eliminating $x_1$ and $y_1$ from $(H)U_1$ and $(P)U_1$, i. e. from the Hessian and the polar point of $(x_1, y_1)$. Or we may obtain the same result by eliminating x and y from the Hessian $(H)U$ and the first polar of $(x_1, y_1)$, $(P)U$. This result is equivalent to the statement that the Steinerian is the locus of all points whose first polars have a point common with the Hessian.

Another group of points closely associated with the Hessian and the Steinerian, designated by G for want of a suitable name, is defined as follows:

*DEFINITION.—The group G is the locus of all first polar points of the Steinerian which do not belong to the Hessian.*

The equation of G is found by eliminating $x_1$ and $y_1$ between the Steinerian, $(S)U = 0$, and $(P_1)U = 0$. Since $(S)U$ is of the degree $2(n-2)$ in $x_1$ and $y_1$, and since $(P_1)U$ is of the first degree in $x_1$ and $y_1$ and of the $(n-1)$ degree in x and y, it follows that this eliminant is of degree $2(n-2)(n-1)$; but since it contains each point of the Hessian as a double point, it will contain the square of the Hessian as a factor. Dividing the eliminant by the square of the Hessian, we obtain the equation of G. The degree of G is therefore $2(n-2)(n-1)-4(n-2) = 2(n-2)(n-3)$. Hence the degree of G is always $(n-3)$ times the degree of the Hessian.

The second polar of each point on the Steinerian has a point common with the Hessian. Denoting by $G_1$ the group of points which are on second polars of the Steinerian and do not belong to the Hessian, we can find the equation of $G_1$ as before by eliminating between $(S)U$ and $(P_1)^2U$ and dividing out the Hessian factor. The third, fourth, etc. to the $(n-1)$th polars of the points of the Steinerian form successive groups which may be designated respectively by $G_2$, $G_3, \ldots G_{n-2}$. The group $G_r$ ($r=2, 3, 4, \ldots n-2$) consists of $2(n-2)(n-r-1)$ points. The last group consists of the $2(n-2)$ polar points of the Steinerian.

We have heretofore considered U to be a non-singular quantic, i. e. to represent a group of points having no double or multiple points. We now proceed to examine the theory of a singular quantic U.

Let the $n$ic have a multiple point of order k, and let this multiple point be taken as one of the ground points of the system of binary coördinates. The quantic may then be written in the form $U=x^kV$. Substituting this value of U in the form for the Hessian,

$$(H)U=\begin{vmatrix} \frac{d^2U}{dx^2} & \frac{d^2U}{dxdy} \\ \frac{d^2U}{dxdy} & \frac{d^2U}{dy^2} \end{vmatrix}=0,$$

it is easily shown that $(H)x^kV$ contains $x^{2(k-1)}$ as a factor. Hence we infer

*THEOREM V.—If U have a multiple point of order k, this point appears as a multiple point of order $2(k-1)$ on $(H)U$.*

We come now to the consideration of the Steinerian of a singular quantic U. It follows from Theorem IV that $(H)U$ and $(S)U$ are two groups of points having a one to one correspondence; hence we may infer from the "correspondence principle" that the Steinerian of U has the same singularities as the Hessian of U.

However this may be proved directly as follows: Let U be written in the form $x^kV$, where V is of order M; then $n=k+m$. But the first polar of any point $(x_1, y_1)$ is of order $(n-1)$ and contains x as a multiple point of order $(k-1)$; to find the Steinerian we have therefore to form the discriminant of a quantic of order $(n-k)$, or $m$. This discriminant, which is the Steinerian less a factor x to a certain power, will contain $x_1$ and $y_1$ to the degree $2(m-1)$; but the Steinerian is of degree $2(n-2)$, therefore x must be contained as a factor $2(n-2)-2(m-1=2(n-m-1)=2(k-1)$ times. We can put this fact into the form of

*THEOREM VI.—If U have a multiple point of order k, this point appears as a multiple point of order $2(k-1)$ on $(S)U$.*

There yet remain to be examined the singularities of the group G, when the group U has a multiple point of order k. Let A be a multiple point of order k on U. The Steinerian then consists of the point A counted $2(k-1)$ times, and $2(n-k-1)$ single points. The first polar of each of these single points consists of the point A counted $(k-1)$ times, and $(n-k)$ other points; so that the first polars of all the single points on the Steinerian consist of the point A counted $2(k-1)(n-k-1)$ times, and $2(n-k)(n-k-1)$ other points. The first polar of the point A on the Steinerian consists of A counted $k$ times, and $(n-k-1)$ other points. But A occurs $2(k-1)$ times on the Steinerian; hence all the first polars of A consist of A counted $2k(k-1)$ times, and $2(k-1)(n-k-1)$ other points. Therefore all the first polars of the Steinerian together contain the point A $2(k-1)(n-1)$ times. But the Hessian contains the point A $2(k-1)$ times, and the square of the Hessian contains it $4(k-1)$ times. Subtracting this number from the above, we have $2(k-1)(n-1)-4(k-1)= 2(k-1)(n-3)$. Therefore the group G contains the point A $2(k-1)+(n-3)$ times.

Besides the multiple point at A, the group G also contains $(n-k-1)$ other multiple points, each of order $2(k-1)$. For, as we pointed out above, the first polar of the point A on the Steinerian consists of the point A counted k times and $(n-k-1)$ other points. But A occurs $2(k-1)$ times on the Steinerian; hence each of these $(n-k-1)$ other points occurs $2(k-1)$ times on the group G.

By subtracting from the order of G the sum of the multiplicities of the multiple points on G, we find the number of single points on G to be $2(n-k-2)(n-k-1)$. We can now sum up the singularities of the group G in the following:

*THEOREM VII.—If U have a multiple point A of order k, this point appears as a multiple point A of order $2(k-1)(n-3)$ on $(G)U$; $(G)U$ also has $(n-k-1)$ other multiple points each of order $2(k-1)$ at the single first polar points of A; consequently, in this case, $(G)U$ has only $2(n-k-2)(n-k-1)$ single points.*

By a process of reasoning similar to that above, it can be shown that the group $G_1$ consists of a multiple point at A of order $2[n(k-2)-(k-3)]$, $(n-k-2)$ multiple points each of order $2(k-1)$ at the single second polar points of A, and $2(k-n-1)$ single points. Similar formulae for the groups $G_2$, $G_3$, . . . etc. might be developed, but they are not especially important.

**JACOBIANS, ETC.**

Let V and W be two quantics, the first of degree $m$ and the second of degree $n$. The determinant formed of the first derivatives of V and W with respect to x and with respect to y, viz:

$$\begin{vmatrix} \frac{dV}{dx} & \frac{dV}{dy} \\ \frac{dW}{dx} & \frac{dW}{dy} \end{vmatrix}$$

is called the Jacobian of V and W. This expression is often written for brevity J(VW). It is readily seen that the equation $J(VW)=o$ is of the degree $(m+n-2)$, and therefore the Jacobian of V and W represents a group of $(m+n-2)$ points. We wish now to determine the geometric properties of the Jacobian.

Let us consider the first polars of any point $(x_1, y_1)$ with respect to V and W. In general these first polars of $(x_1, y_1)$ are distinct groups of points; but for certain positions of $(x_1, y_1)$ these two first polars may have a common point. The equation of the locus of the points common to these first polars is readily found. For the first polars of $(x_1, y_1)$ with respect to V and W are given respectively by

$$(P_1)V = x_1\frac{dV}{dx}+y_1\frac{dV}{dy}=o,$$

$$(P_1)W = x_1\frac{dW}{dx}+y_1\frac{dW}{dy}=o.$$

We obtain the equation of the common points of these two groups by eliminating $x_1$ and $y_1$ from these two equations. But this eliminant is J(VW); Hence our first geometric property may be stated in the form of

*THEOREM VIII.—The Jacobian of two quantics V and W is the locus of all points common to the first polars of a point with respect to V and W.*

The equation $J(VW)=o$ may also be obtained from another consideration which leads to a second important geometric property of the Jacobian of two quantics. The polar points of $(x_1, y_1)$ with respect to V and W respectively are given by

$$(P)V_1 = x\frac{dV_1}{dx_1}+y\frac{dV_1}{dy_1}=o,$$

$$(P)W_1 = x\frac{dW_1}{dx_1}+y\frac{dW_1}{dy_1}=o.$$

These points coincide when their eliminant vanishes, i. e., when

$$\begin{vmatrix} \frac{dV_1}{dx_1} & \frac{dV_1}{dy_1} \\ \frac{dW_1}{dx_1} & \frac{dW_1}{dy_1} \end{vmatrix} = o.$$

But when $(x_1, y_1)$ are taken as the variable point, this is no other than the Jacobian of V and W. Hence our second geometric property of the Jacobian may be stated as follows:

*THEOREM IX.—The Jacobian of two quantics V and W is also the locus of all points whose polar points with respect to V and W coincide.*

In the particular case when V and W are of the same degree $n$, their Jacobian has still another important geometric meaning. The equation $V+kW=o$, where $k$ is a variable parameter, is the equation of an involution of the $n$th order. The equation of the double points of this involution may be readily found. For if $V+kW=o$ has a double point, its x and y derivaties are simultaneous equations and their resultant vanishes. Thus,

$$\frac{dV}{dx}+k\frac{dW}{dx}=o,$$

$$\frac{dV}{dy}+k\frac{dW}{dy}=o.$$

Eliminating $k$ we have

$$\begin{vmatrix} \frac{dV}{dx} & \frac{dW}{dx} \\ \frac{dV}{dy} & \frac{dW}{dy} \end{vmatrix} = o.$$

But this is the equation of the Jacobian as otherwise defined; whence we have

*THEOREM X.—When the two quantics V and W are of the same degree n, they determine an involution of the nth order; the Jacobian of V and W in this case is the equation of the 2(n—1) double points of this involution.*

The Jacobian of any two groups belonging to an involution of the $n$th order is the same as that of any other two groups of the same involution. For the Jacobian of the two groups $V+k_1W=o$ and $V+k_2W=o$ is found to differ from the Jacobian of V and W only by a common factor which involves $k_1$ and $k_2$. Thus

$$\begin{vmatrix} \frac{dV}{dx}+k_1\frac{dW}{dx} & \frac{dV}{dx}+k_2\frac{dW}{dx} \\ \frac{dV}{dy}+k_1\frac{dW}{dy} & \frac{dV}{dy}+k_2\frac{dW}{dy} \end{vmatrix} = \begin{vmatrix} \frac{dV}{dx} & \frac{dW}{dx} \\ \frac{dV}{dy} & \frac{dW}{dy} \end{vmatrix} \times \begin{vmatrix} 1 & k_1 \\ 1 & k_2 \end{vmatrix} = o.$$

If one of the quantics, W for example, be of the first degree, it represents a single point; the Jacobian of V and W must now have some new meaning, for we can no longer properly speak of the polar of a point with respect to W.

The equation of the first polar of $(x_1, y_1)$ with respect to V is given by the operation $\left\{x_1 \frac{d}{dx} + y_1 \frac{d}{dy}\right\} V = o$, or $\left\{\frac{x}{y_1} \frac{d}{dx} + \frac{d}{dy}\right\} V = o$. If the equation of W be given in the form $ax_1 + by_1 = o$, the equation of the first polar of W with respect to V may be obtained by substituting $-\frac{b}{a}$ for $\frac{x_1}{y_1}$ in the above operation for the polar. Making this substitution we have $\left\{-b\frac{d}{dx} + a\frac{d}{dy}\right\} V = o$; but $a = \frac{dW}{dx}$ and $b = \frac{dW}{dy}$. Whence the last equation gives

$$\frac{dW}{dx}\frac{dV}{dy} - \frac{dW}{dy}\frac{dV}{dx} - \begin{vmatrix} \frac{dW}{dx} & \frac{dW}{dy} \\ \frac{dV}{dx} & \frac{dV}{dy} \end{vmatrix} = o.$$

which is the Jacobian of V and W. Whence we have

*THEOREM XI.—When one of the quantics V and W, W for example, is of the first degree, J(VW) becomes the first polar of the point W with respect to V.*

When the two quantics V and W are so related that one of them is the Hessian of the other, e. g., $W = H(V)$, then the Jacobian of the two groups of points V and H is called for brevity the Jacobian of V. Thus the Jacobian of any quantic U whose Hessian is H, is given by

$$\begin{vmatrix} \frac{dU}{dx} & \frac{dU}{dy} \\ \frac{dH}{dx} & \frac{dH}{dy} \end{vmatrix} \quad o.$$

(See Harkness and Morley's Theory of Functions, Chap. I.)

If V be of degree $n$, its Hessian as we know is of degree $2(n-2)$; therefore the Jacobian of V is of degree $[(n-1)+2(n-2)-1]$ or $3(n-2)$.

### THE FUNCTION M(VW).

Closely associated with the Jacobian of two groups of points V and W is another group which I shall designate by M(VW). The function M bears much the same relation to the Jacobian that the Steinerian bears to the Hessian. This new group of points may be defined as follows:

*DEFINITION.—$M(VW)$ is the locus of all points $(x_1, y_1)$ whose first polars with respect to $V$ and $W$ have a common point; these common points of course constitute the Jacobian.*

The equation of M(VW) is obtained by eliminating x and y from the equations of the first polars of $(x_1, y_1)$ with regard to V and W, viz:

$$x_1\frac{dV}{dx}+y_1\frac{dV}{dy}=0,$$

$$x_1\frac{dW}{dx}+y_1\frac{dW}{dy}=0.$$

Since these first polars are respectively of degrees $(n-1)$ and $(m-1)$ in x and y, and since each contains $x_1$ and $y_1$ in the first degree only; it follows that their resultant will contain $x_1$ and $y_1$ in the degree $(n+m-2)$. Hence M(VW) represents $(n+m-2)$ points and is always of the same degree as the Jacobian.

The equation of M(VW) can also be obtained from another elimination, the consideration of which leads us to an important geometric property of this group of points. The polar points of $(x_1, y_1)$ with respect to V and W are respectively

$$x\frac{dV_1}{dx_1}+y\frac{dV_1}{dy_1}=0;$$

$$x\frac{dW_1}{dx_1}+y\frac{dW_1}{dy_1}=0.$$

By eliminating $x_1$ and $y_1$ from these two equations, we obtain the locus of all the points at which the polar points of $(x_1, y_1)$ with respect to V and W coincide. But the equation thus obtained is no other than $M(VW)=0$ obtained by the former elimination. We are now able to state

*THEOREM XII.—The group of points represented by $M(VW)$ is the locus of the polar points of $V$ which coincide with polar points of $W$; i. e., it is the locus of the polar points of the Jacobian with respect to either $V$ or $W$.*

The whole theory of the Jacobian and the function M(VW) may now be condensed and stated in the following comprehensive theorem;

*THEOREM XIII.—If the first polars of a point $A$ with respect to two groups of points $V$ and $W$ have a common point at $B$, then the polar points of $B$ with respect to $V$ and $W$ coincide at $A$; and vice versa. The locus of all points $B$ is the Jacobian of $V$ and $W$, and the locus of all points $A$ is the function $M(VW)$.*

From the relations between J(VW) and M(VW) pointed out above we see that the equation of M(VW) may be obtained by eliminating

x and y from J(VW) and the first polar of $(x_1, y_1)$ with respect to either V or W; i. e., $x_1\frac{dV}{dx}+y_1\frac{dV}{dy}=0$, or $x_1\frac{dW}{dx}+y_1\frac{dW}{dy}=0$. Or, what amounts to the same thing, by eliminating $x_1$ and $y_1$ from $J(V_1W_1)$ and the polar points of $(x_1, y_1)$ with respect to either V or W; i. e., $x\frac{dV_1}{dx_1}+y\frac{dV_1}{dy_1}=0$, or $x\frac{dW_1}{dx_1}+y\frac{dW_1}{dy_1}=0$.

When the two quantics V and W are of the same degree $n$, they determine an involution of the $n$th order. The function M for the groups V and W of this involution is the same as for any other two groups V and W. For M(VW) is defined as the locus of the polar points of the Jacobian of V and W with respect to either V or W. If now instead of W we take another group W′ belonging to the same involution, the Jacobian of V and W′ is the same as that of V and W; and consequently M(VW′) is the same as M(VW). Again if we take another group V′ instead of V, it may be shown in the same way that M(V′W′) is the same as M(VW′). Hence we may speak of the function M for an involution just as we speak of the Jacobian of an involution.

It has been shown that when W is of the first degree the Jacobian of V and W is the first polar of W with respect to V. It is also known from the theory of poles and polars that, if $p_1, p_2, p_3, \ldots p_{n-1}$ be the $n-1$ first polars of W with respect to V, then W is the polar point with respect to V of each of the points $p_1, p_2, \ldots p_{n-1}$. Hence when W is of the first degree, there is no group M(VW) other than the point W.

When the two quantics V and W are so related that W is the Hessian of V, there is a group of points M(V) of the same order as the Jacobian of V, which is the locus of all polar points of J(V) with respect to V. (This group of points M(V) is an important covariant of V; but it is not, like J(V), a fundamental covariant of V.)

Heretofore we have implicitly assumed that V and W were both non-singular quantics, i. e., that neither of them had a multiple point; (a multiple element is the only singularity which a one dimensional geometric form can have). We shall now proceed to examine the functions J(VW) and M(VW) when one or both the quantics have a multiple point.

Suppose that V has a multiple point of order $k$, then this same point will appear as a multiple point of order $(k-1)$ on each of the first polars of V. Consequently it will appear as a multiple point of order $(k-1)$ on the Jacobian of V and W. This may also be shown analytically by choosing the multiple point for one of the ground

points of the co-ordinate system; for the quantics may then be written $x^k V_1$ and W. Forming the Jacobian we have

$$J(VW)=\begin{vmatrix} kx^{k-1}V_1+x^k\frac{dV_1}{dx} & x^k\frac{dV_1}{dy} \\ \frac{dW}{dx} & \frac{dW}{dy} \end{vmatrix}$$

$$x^{k-1}\begin{vmatrix} kV_1+x\frac{dV_1}{dx} & x\frac{dV_1}{dy} \\ \frac{dW}{dx} & \frac{dW}{dy} \end{vmatrix}=0.$$

The last determinant will not contain x as a factor unless $V_1$ or W contains it, a condition implicitly excluded by hypothesis. Whence we infer the following theorem:

*THEOREM XIV.—A multiple point of order k on either V or W will appear as a multiple point of order (k—1) on the Jacobian of V and W.*

Next let us suppose that a given point P is a common multiple point of both V and W; let us assume that it is a multiple point of order $k$ on V and of order $k'$ on W. Taking P as one of the ground points of the cordinate system, the two quantics may be written in the form $x^k V_1$ and $x^{k'} W_1$. Let it be assumed that V and W are of degrees $n$ and $m$ respectively, and that $V_1$ and $W_1$ are respectively of degrees $n'$ and $m'$.

The Jacobian of these two quantics may be written:

$$J(VW)\begin{vmatrix} kx^{k-1}V_1+x^k\frac{dV_1}{dx} & x^k\frac{dV_1}{dx} \\ k'x^{k'-1}W_1+x^{k'}\frac{dW_1}{dx} & x^{k'}\frac{dW_1}{dy} \end{vmatrix}=0.$$

From this we can factor out $x^{k+k'-1}$ and have left the determinant

$$x^{k+k'-1}\begin{vmatrix} kV_1+x\frac{dV_1}{dx} & \frac{dV_1}{dy} \\ k'W_1+x\frac{dW_1}{dx} & \frac{dW_1}{dy} \end{vmatrix}=0.$$

Since $V_1$ is if order $n'$ and $W_1$ of order $m'$, by Euler's theorem of homogeneous functions $n'V_1=x\frac{dV_1}{dx}+y\frac{dV_1}{dy}$ and $m'W_1=x\frac{dW_1}{dx}+y\frac{dW_1}{dy}$. Substituting these values of $V_1$ and $W_1$, we have

$$J(VW) = \frac{x^{k+k'-1}}{m'n'}\begin{vmatrix} kx\frac{dV_1}{dx} + ky\frac{dV_1}{dy} + n'x\frac{dV_1}{dx} & n'\frac{dV_1}{dy} \\ k'x\frac{dW_1}{dx} + k'y\frac{dW_1}{dy} + m'x\frac{dW_1}{dx} & m'\frac{dW_1}{dy}\end{vmatrix} = 0,$$

$$= \frac{x^{k+k'-1}}{m'n'}\begin{vmatrix} (k+n')x\frac{dV_1}{dx} + ky\frac{dV_1}{dy} & n'\frac{dV_1}{dy} \\ (k'+m')x\frac{dW_1}{dx} + k'y\frac{dW_1}{dy} & m'\frac{dW_1}{dy}\end{vmatrix} = 0,$$

$$= \frac{x^{k+k'-1}}{m'n'}\left( x\begin{vmatrix} (k+n')\frac{dV_1}{dx} & n'\frac{dV_1}{dy} \\ (k'+m')\frac{dW_1}{dx} & m'\frac{dW_1}{dy}\end{vmatrix} + y\frac{dV_1}{dx}\frac{dW_1}{dy}\begin{vmatrix} k & n' \\ k' & m'\end{vmatrix}\right) = 0.$$

From this last result we see that generally x is contained in J(VW) as a factor $(k+k'-1)$ times; we also see that, when the determinant $\begin{vmatrix} k & n' \\ k' & m'\end{vmatrix} = 0$, x is contained once more in J(VW). Putting $\begin{vmatrix} k & n' \\ k' & m'\end{vmatrix} = 0$, we have $km' = k'n'$. $\therefore \frac{k}{k'} = \frac{n'}{m'} = \frac{k+n'}{k'+m'} = \frac{n}{m}$. Making these substitutions in the last equation and omitting constant factors, we have

$$J(VW) = x^{k+k'}\begin{vmatrix} \frac{dV_1}{dx} & \frac{dV_1}{dy} \\ \frac{dW_1}{dx} & \frac{dW_1}{dy}\end{vmatrix} = 0.$$

These important results may be formulated as follows:

*THEOREM XV.—If a point P be a multiple point of order k on V and of order k' on W, where V and W are two quantics of degrees n and m respectively; then, when $km - k'n \neq 0$, P is a multiple point of order $(k+k'-1)$ on J(VW); but when $km - k'n = 0$, P is a multiple point of order $(k+k')$ on J(VW).*

When the two quantics V and W are of the same degree $n$ and at the same time the condition $km - k'n = 0$ is satisfied, then must $k = k'$. The Jacobian then contains $x^{2k}$ as a common factor.

*THEOREM XVI.—When two groups of points V and W of the the same degree have a common multiple point of order k, this appears as a multiple point of order 2k on their Jocobian.*

(See Salmon's Higher Algebra, Art. 178.)

Since the two groups of points (J(VW) and M(VW) have a one to one correspondence, it follows from the "correspondence principle"

that they must have the same singularities For this reason it does not seem necessary to give a formal discussion of the singularities of the function M(VW). It may be readily verified in each particular case that a singularity on J(VW) appears also on M(VW). When either V or W has a multiple point, or when the two have a common multiple point, the results may be readily obtained from Theorems XIII, XIV, and XV by simply changing J(VW) into M(VW). But it is better, however, to write out the results for future reference.

*THEOREM XVII.--A multiple point of order k on either V or W will appear as a multiple point of order $(k-1)$ on M(VW).*

*THEOREM XVIII.--If a point P be a multiple point of order k on V and of order k' on W, where V and W are two qnantics of degrees n and m respectively; then, when $km-k'n\pm 0$, P is a multiple point of order $(k+k'-1)$ on M(VW); but when $k'm-kn=0$, P is a multiple point of order $(k+k')$ on M(VW).*

*THEOREM XIX.—When two groups of points V and W of the same degree have a common multiple point of order k, this appears as a multiple point of order 2k on M(VW).*

It yet remains to point out the obvious truth that, when V and W are first polars of a third quantic U, the Jacobian of V and W is the same as the Hessian of U; and the function M(VW) then becomes the Steinerian of U. It will prove to be an interesting exercise for the reader to compare the propositions concerning the Hessian of U with those for the Jacobian of V and W; also the Steinerian of U with M(VW), and thus verify in detail the correctness of the whole.

I hope to be able in the near future to prepare a paper discussing in detail the application of these theorems to the linear geometry of Cubic, Quartic, and Quintic.

# Irrigation along the Arkansas in Western Kansas.

BY E. C. MURPHY, C. E.,
Member of the American Society of Irrigation Engineers.

Some eight months ago the writer was asked to compute the horse-power and give his opinion of a new design of wind-mill by a Western Kansas man. Since then he has devoted considerable time to the subject of irrigation in Kansas and to the use of wind-mills in connection therewith. During the last two weeks of July he made a trip with his wheel up the Arkansas Valley, visiting nearly all the canals and their head works along the river up to Pueblo. The facts presented herein he has gathered from observation, conversation with canal officials and others, and from the U. S. Reports on irrigation in the arid region. He desires herewith to thank those who have so kindly furnished him with maps and information on this subject.

We will consider briefly the rainfall, the evaporation, the winds, the quantity of water available in the river, and the ground, the part of this water used by the people of Colorado, and lastly the irrigation works. In the discussion of the first two we will include the region from Dodge City to Pueblo.

The rainfall in this region may be seen from the records of four places in it. Table I gives the names of these places, the length of their record, the mean annual rainfall, the amount, percentage amount, and least amount of rain which falls during the four irrigating months, May, June, July, and August.

TABLE I.

| NAME. | Period. | Mean annual rainfall. | Rainfall in 4 mos. | Perc. fall in 4 mos. | Least fall in 4 mos. |
|---|---|---|---|---|---|
| Dodge City.. | 14 yrs. | 20 19 in. | 13 77 in. | 66 | 8.24 in. |
| Ft. Wallace. | 5 " | 13 21 " | 7.69 " | 58 | 4.33 " |
| Las Animas and Ft Lyon | 19 " | 12 25 " | 7 89 " | 65 | |
| Pueblo.... | 8 " | 12.67 " | 6.95 " | 55 | |

It may be seen from this table that the mean annual rainfall in nearly all of this region is about 13 inches; in the eastern part it increases to about 22 inches. From 55 to 66 per cent of this mean yearly precipitation falls during the four irrigating months.

It is well to note the fact that an inch of water in rainfall is in general not as beneficial as an inch of water applied to the soil by the irrigator, because the rain often falls so rapidly that 50 per cent of it runs off in the drainage channels without soaking into the ground, and secondly the rain does not always come at a time when most needed. If the irrigator has plenty of water, he can apply it to the soil when it will do the most good and withhold it when it is not needed. The number of inches of water required to mature a crop minus the number of inches of rainfall during the irrigating season gives the number of inches of water the irrigator must supply.

Very few measurements have been made of the evaporation in this region. The following at Dodge City and Colorado Springs were made in 1888 by Mr. T. Russell, of the U. S. Signal Service:

Dodge City, yearly evaporation, 54.6 inches: Evaporation for the four irrigating months, 27.8 inches. Colorado Springs, yearly evaporation, 59.4 inches: evaporation for the 4 irrigating months, 23.8 inches.

The 28 inches evaporated from the surface of water minus the 7 to 14 inches of rainfall leaves a resultant evaporation loss from water surfaces during the four irrigating months of from 21 to 14 inches. This water would irrigate an area larger than that of the water surface.

The temperature and dryness of the winds have much to do with the amount of water required for irrigating, but it is the velocity of the wind in connection with air motors for working pumps to raise water that we wish to consider. The direction of the prevailing wind is also of interest, as some of the wind-mills are constructed on the assumption that this direction is north and south or nearly so.

Through the kindness of the Chief of the U. S. Weather Bureau I am able to give, in Table II, the average number of hours per month, for the four irrigating months, that the velocity of the wind was 0 to 5, 6 to 10, 11 to 15, 16 to 20, 21 and upwards miles per hour at Dodge City. These means are for the four years 1889 to 1892 inclusive.

TABLE II.

| | | 0 to 5 | 6 to 10 | 11 to 15 | 16 to 20 | 21 and upwards |
|---|---|---|---|---|---|---|
| May | Max | 126 | 198 | 208 | 149 | 183 |
| | Min | 111 | 166 | 144 | 87 | 90 |
| | Mean | 118 | 189 | 178 | 126.5 | 133.25 |
| June | Max | 155 | 237 | 167 | 145 | 222 |
| | Min | 85 | 152 | 105 | 73 | 108 |
| | Mean | 123.5 | 190 | 136.5 | 115.5 | 155.25 |
| July | Max | 186 | 236 | 195 | 134 | 117 |
| | Min | 114 | 179 | 156 | 112 | 84 |
| | Mean | 143 | 213.5 | 172.25 | 117.5 | 95.25 |
| August | Max | 224 | 267 | 185 | 149 | 176 |
| | Min | 88 | 165 | 121 | 94 | 58 |
| | Mean | 156.5 | 217.5 | 160 | 112.5 | 97.5 |
| Sum | | 541 | 810 | 617 | 472 | 481 |

From Table II we see that at Dodge City the wind has a velocity of 6 miles or more per hour for 83 per cent of the time, and a velocity of 11 miles and upwards per hour for 54 per cent of the time. It is customary to assume that a wind-mill will run for 33⅓ per cent of the time, but from the above it is evident that a wind-mill properly designed will work in this region a much larger per cent of the time.

As regards the direction of the prevailing winds we have the following table prepared from the U. S. Weather Bureau Report for 1891-92, which gives the number of hours during the four irrigating months that the prevailing direction of the wind was as indicated at the head of each column at Dodge City.

TABLE III.

| | N. | N. E. | E. | S. E. | S. | S. W. | W. | N. W. | Calm. |
|---|---|---|---|---|---|---|---|---|---|
| 1891 | 275 | 325 | 140 | 299 | 1387 | 206 | 59 | 224 | 8 |
| 1892 | 382 | 418 | 167 | 1334 | 322 | 82 | 67 | 141 | 9 |

From this table we see that for these years the prevailing direction was north or south 40 per cent of the time, N. E. or S. W. 18 per cent af the time, and N. W. or S. E. 34 per cent of the time. These results indicate that the proper direction for the axis of an overshot wheel is nearly N. E.

The Arkansas river is a mountain stream as distinguished from other rivers which flow through and rise in the plains, which are called plain rivers. It rises in the snow-covered mountains of central Colorado. Much of its flood-flow is from its tributaries which rise in the foot-hills and plains; the part of its water which is used for irrigating comes mainly from the mountains. The precipitation in the mountains at the upper end of the valley is much greater than that in the valley in the plains, and falling as snow is blown by the winds into the ravines and gulches filling them in places to a depth of more than fifty feet. This slowly melting snow supplies most of the water during July and August. The principal tributaries are the Big Sandy from the north and the Purgatoire, Las Animas, Apishapa, Huerfano and St. Charles from the south. These empty into the river below Pueblo.

Table IV gives measurements of the flow of the river at a few points and the drainage area above each point.

The daily gaugings at Canon City for 1891 show that the river began to rise about May 1st, reached a maximum about June 1st, then gradually decreased till Aug. 6th, when the flow was about the same as May 1st.

A few measurements of the flow of the Huerfano and Purgatoire have been made, but not enough to be of much value. They show this, however, that the minimum flow is very small, and the flood

TABLE IV.

| Place. | Drainage. Area sq. miles. | Time. | Maximum cu. ft. sec. | Minimum cu. ft. sec. | Mean cu. ft. sec. |
|---|---|---|---|---|---|
| Canon City.... | 3,060 | Year ending Dec. 31. '88. | 2,760 | 430 | 800 |
| " " ... | 3,060 | " " " '89. | 2,620 | 190 | 433 |
| " " .... | 3,060 | " " " '90. | 3,370 | 180 | 874 |
| " " .... | 3,060 | " " " '91. | 4,230 | 32.5 | 1.012 |
| Rock Canon... | 4,560 | May to August, '89. | 4,375 | 40.5 | 1.210 |
| Pueblo ........ | 4,600 | Year ending Dec. '86. | 7,659 | 400 | 1,441 |
| " ........ | 4,600 | " " " '87. | 6,510 | 400 | 1,323 |
| La Junta...... | 12,200 | May 20 to August 31, '89. | 2,620 | 55 | 931 |

flow large and sudden, due to cloud-bursts and the sudden melting of snow. The same is true of the other tributaries which we have mentioned.

From this table we see that the discharge of the river at any point varies much from year to year; thus the mean discharge at Canon City in 1891 was 2½ times that at the same place in 1889.

Table V, which we have compiled from the report of the State Engineer of Colorado for 1889-90, gives data for eleven water districts of the Arkansas and its tributaries. Column one gives the number of the district, two the name of the principal stream in the district—from which the location of the district may be seen, three the number of canals in the district, four the decreed capacity of the canals, five the computed capacity in case a court decree has not been obtained.

TABLE V.

| No. | Name of principal stream. | No. Canals. | Decreed Capacity cu. ft. sec. | Computed Capacity. | REMARKS. |
|---|---|---|---|---|---|
| 10 | Fountain qui Bouille. | 64 | ....... | 1107.60 | Capacity of two not given. |
| 11 | Arkansas. | 190 | 672 67 | ....... | |
| 12 | " | 149 | 1062.50 | 6765.10 | |
| 13 | Grape Creek. | 27 | ....... | 36.33 | This the capacity of 14 only. |
| 14 | Arkansas. | 14 | ....... | 7070 57 | |
| 15 | St. Charles. | 48 | ....... | 73 22 | This the am't carried in 1890. |
| 16 | Huerfano. | 132 | 401 74 | 162.27 | |
| 17 | Arkansas. | 16 | 1315.00* | 2688 53 | *This the average amount carried in 1890 by seven. |
| 18 | Apishapa. | 4 | ...... | 57 46 | |
| 19 | Purgatoire. | 29 | 217 95† | 391.61 | †This the am't decreed to 11. |
| 67 | Arkansas. | 27 | .. .... | 9781.00 | Capacity of four not given. |
| | | | 3609.86 | 28133.59 | |

Five of the canals in Dist. No. 10, constructed prior to 1888, have a capacity of 71 cu. ft. per sec.; 142 in Dist. No. 11, constructed prior to 1888 have a capacity of 581 cu. ft. per sec.; 121 in Dist. No. 12 were constructed prior to 1888.

From this table we see that the capacity of the canals in these districts is at least 41,743 cu. ft. per sec. This is more than five times

the greatest maximum flow of the river as given in table III. The question naturally arises, where does the water come from to supply these canals? It is true that at times there is not water enough in the river and its tributaries to supply this capacity, but there has been plenty this year. It has not been necessary this year to restrict the amount which any canal could take, and near the end of July when I passed through, there was enough in the river east of the Colorado line to supply all the canals in Kansas along the river. May it not be that some of the water is used two or more times for irrigating? That such is the case on the Cache la Poudre, a tributary of the Platte in northern Colorado, the following measurements will show. Measurements of this stream in 1889 showed that the discharge at one point was 127.6 cu. ft. per sec. while at a point lower down the stream it was found to be 214.5 cu. ft. per sec. after supplying 15 canals and without receiving additional natural drainage. This is an increase in the flow of this stream of 60 per cent. after supplying the 15 canals. In the upper valley of the Arkansas much of the water which some canals take from the river is returned directly to it. A man who has a large farm in the upper valley and who owns two canals taking water from the Arkansas, told the writer that he kept his grass land under slowly moving water much of the time. The water from his ditches flows gently over his land and then directly back into the river.

It is evident from the above tables and discussion that the amount of water which can be taken from the Arkansas in western Kansas is small and is available only during June and a part of May and July, therefore water to irrigate this region must be gotten mainly from beneath the surface. The amount of underground or underflow water and its distance from the surface is therefore very important.

The subject of the underflow of the Plains has been investigated by the U. S. Dept. of Agriculture. This investigation for the Arkansas valley consisted in running three stadia lines north and south across the valley, thus getting the elevations of wells and their distances apart on or in the vicinity of the lines. The distance from the surface to water in each well, and the strata passed through were noted. Thus the position and inclination of the upper surface of this underground water was ascertained. These lines are known as the Garden City, Dodge City, and Great Bend lines. The latter being east of the eastern limit of the Arid Region will not be considered.

The Garden City line extends from a point on Ladder Creek, a branch of the Republican, about 42 miles north of Garden City, to

Loco, a place about 40 miles south of Garden City. The surface of the water is shown from the wells along this line to be inclined south at a nearly uniform rate of 2.4 feet to the mile, the difference in elevation of the water surface at the ends of the line being 220 feet. North of Garden City the surface of the country slopes south so that this water is quite near the surface. South of Garden City the surface slopes in the opposite direction to that of the water surface, hence the wells are deep. Near the south end of the line they are 200 feet deep.

The Dodge City line extends from a point on the Pawnee Fork, about 34 miles north of Dodge to a point 10 miles south, thence southwest 25 miles to Fowler, Meade Co. North of the river the wells on this line show no well defined water-bearing stratum. In a few of them the water is a little above that in the river, in most of them it is below river level. South of the river this water surface is well defined and slopes a little to the south. The wells are deep, the surface of the country being high.

This water-bearing stratum is sand or gravel, or a mixture of these. Its thickness varies a good deal. In some places it is so thin that the wells pass through it, in others it is of unknown thickness. An experimental well at Garden City showed it to be 320 feet in thickness at that place.

From observations at a few places it appears that this body of water is moving very slowly from northwest to southeast.

The source of this underflow is important, for this water-bearing stratum is a vast reservoir filled with water; when the quantity of water taken from it yearly is greater than that supplied to it, its surface must lower, and eventually the supply will give out. It was formerly thought that this water comes from the mountains, brought down by streams. The underflow investigation, referred to above, seems to show that such is not the case. Take the Garden City line, for example, the water in the wells north of the Arkansas is at a greater elevation than that in the river, hence this water cannot come from the Arkansas. The water at the north end of this line is more than 200 feet above that in the Platte river, hence it cannot come from this mountain stream. It is believed by some to come from the rainfall on the Plains. Some streams which rise in Eastern Colorado and Western Kansas disappear in a low area in Scott, Finney and Kearney counties and are thought to supply the underflow of this area. It cannot, however, be said to be proved that all the underflow of the Plains comes from the rainfall on the Plains. Be the source of this underflow what it may, wells in it which have furnished

a large amount of water for years show no sign of failure or diminution.

This water must be raised to the surface before it is available for use. Two methods of doing this are in use, that of a long reservoir or canal whose bed is below the surface of the underflow water and into which it gradually collects and either runs off by gravity or is pumped out into a canal. The second method, and the only one now used, is to drive one or more well points down into the underflow stratum, attach a pump and operate the pump by windpower.

The canals in the Arkansas valley in western Kansas are shown on the accompanying map and will be described in the order their headworks are found in going up the river.

The South Dodge Canal was constructed in 1889 by the South Dodge Canal Co. It is located on the south side of the river and irrigates bottom land only. It was the intention of the owners to get all the water for this canal from the underflow but they have found it impossible so to do, and three years ago a channel was cut to the river and now nearly all the water carried by this canal is taken directly from the river. The head of this canal is about 9 miles west of Dodge. The canal is 15 miles long, has 20 miles of laterals, is 15 ft. wide at the bottom, 25 ft. wide at the top, 3½ ft. deep, has a grade of from 2 to 3 ft. to the mile and a carrying capacity of 75 cu. ft. per sec.

The foundation or underflow ditch from which the water was to be gotten is 1¼ miles long, 50 ft. wide, and extends along the river from 100 to 200 ft. from it. The fall of the river being 7 ft. to the mile and that of the underflow ditch 2 ft., the upper end of this ditch was 6¼ ft below the bed of the river, and thus the water from the river and the underflow on the other side of ditch gradually found its way into the ditch by seepage. The sand is gradually flowing in and filling up this fountain, and the owners see that it is cheaper and better to pump the water from a small area or well than to try to collect it in a long ditch. The cost of the works was $50,000, one-half of which was spent on the fountain. It commands an area of 15,000 acres.

The Eureka canal was constructed during the years 1884-88 by the Eureka Canal Co.; it is now owned by the Western Kansas Water Works & Irrigation Co. It is 96 miles long and has 150 miles of laterals. It is 40 ft. wide at the top, 25 ft. at the bottom, 5 ft. deep, and has a carrying capacity of 300 cu. ft. per sec. It leaves the river on the north side at a point about 1½ miles west of Ingalls. It has a fountain or underflow ditch at its head constructed in 1886 and '87, extending about ¾ mile up along the side of the river from

the headgates. There is a dam across the underflow ditch near its lower end and two centrifugal pumps, the intention being to pump the underflow into the main canal. The head-works consist of a wing dam made of sod, brush and sand-bags for deflecting the water into the canal; six gates 4x6 ft. set in wooden frames for regulating the amount of water admitted to the canal. About ½ mile down the canal from the head gates are the waste gates, similar to the head gates. This canal is designed to irrigate the upland. It has a grade of from two to three feet per mile for the first 45 miles or until it reaches the divide; thence it follows the divide, the grade being much greater in some places. At one point there is a drop of 20 feet. It throws out laterals on both sides and commands a large area of country. There are 80 reservoir sites on the canal, varying in size from 10 to 160 acres and from 2 to 50 feet deep. The total cost of the work was $700,000, or an average cost of $7292 per mile. On the table land the cost was from $200 to $300 per mile. The present owners have ceased operations for the present, and a few individuals are operating the canal and using the water down to Cimaron, 7 miles from the head.

The Garden City canal is the oldest irrigating canal in the Arkansas valley in Kansas. Its construction was commenced by private individuals in 1879. The first chartered company was the Garden City Irrigation, Water Power and Manufacturing Co.; the present owners are the Garden City Irrigation Co. This canal is on the north side of the river, is 10 miles long, has 20 miles of laterals, and irrigates bottom land only. It is 20 ft. wide at bottom, 30 ft at top; is 3 ft. deep, has a grade of 2 to 2½ ft. to the mile, and a carrying capacity of 200 cu. ft. per sec. The head-works are located 4 miles west of Garden City and consists of a dam made of sods and sand-bags extending about 200 ft. up and out into the river, eight 4x5 ft. gates for regulating the amount of water which enters the canal and six similar gates near by for allowing the water not taken into canal to pass into a waste-way and thus back into river. The cost of the works was $15,000, and the annual charge for water is $1.25 to $2.00 per acre. It commands an area of 10,000 acres.

The Kansas canal is designed to irrigate a portion of the bottom and upland. Its construction was commenced in 1880 by individuals. The first chartered company that had possession of it was the Kansas Irrigation, Water Power and Manufacturing Co. It is now owned by the Garden City Irrigation Co. It is located on the north side of the river; is 20 miles long and has 30 miles of laterals; is 20 ft. wide at bottom and 30 ft. at the top, 3½ ft. deep; has a grade of 2½ ft. to the mile and has a capacity of 350 cu. ft. per sec.

The head works are similar to those of the Garden City canal, and are located ½ mile southeast of Deerfield. The total cost of the work was $35,000; the annual rental is from $1.25 to $2.00 per acre. The canal commands an area of 20,000 acres.

The South Side canal was constructed in 1883 by individuals. It is located on the south side of the river and is designed to irrigate bottom land only. It is 25 miles long and has 40 miles of laterals; is 20 ft. wide at bottom, 3½ ft. deep, and has the same grade as the land irrigated. The head-works are located 1½ miles west of Hartland, and consists of a wing dam of sod and sand bags, a set of gates 40 ft. wide and a fountain or underflow ditch. The total cost of this work was $200,000; the annual rental is $1.50 per acre. It commands an area of 50,000 acres, 25,000 of which are said to be irrigated.

The Southwestern canal, formerly called the Great Eastern, was constructed in 1881 by the Great Eastern Irrigation Water Power Co. The present owners are the Southwestern Irrigation Co. It is located on the north side of the river and is designed to irrigate the upland. It is 40 miles long and has 85 miles of laterals; its bottom width is 16 ft., its top width 31 ft., depth 4¾ ft., its grade is 3 ft. to the mile, and it has a carrying capacity of 500 cu. ft. per sec. There are two reservoirs on the canal, having an area of 1800 acres. The head-works, a sketch of which is shown in fig. 1, are located about

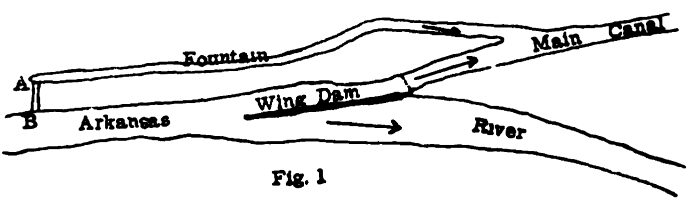



Fig. 1

½ mile west of Hartland. They consist of a wing dam, five gates for admitting the proper amount of water into canal, a waste way with six gates, and an underflow ditch. This underflow ditch, like the others already described, has not proven a success, and a couple of years ago the channel A B was cut to the river at the upper end of the fountain, thus enabling water to be taken direct from the river at two places. The amount invested in this canal and head-works is $60,000; the annual rental is $2.00 per acre. It commands an area of 50,000 acres, 10,000 of which are said to be irrigated.

The Amazon canal was partly constructed in 1887-8 by the Amazon Irrigation Co. and was reconstructed in 1891 by the Southwestern Kansas Land and Irrigation Co. The present owners are the Syndicate Land and Irrigation Corporation. It is the longest canal in

Kansas, and is designed to irrigate the upland. It is 99½ miles long and has 75 miles of laterals; it is 24 ft. wide at bottom, 4 ft. deep, has a grade of 2½ ft to the mile, and a carrying capacity of 400 cu. ft. per sec. The head-works, which are located 3½ miles west of Hartland, consist of a wing dam, head gates and waste gates similar to those of the Garden City canal. The cost of the canal and head-works was $325,000. It commands an area of 34,000 acres, 2000 of which are irrigated.

The lower Alamo canal was constructed in 1878, the upper one in 1890. The lower one leaves the river on the north side about 4 miles, and the upper one about 8 miles west of Syracuse. Their combined length is 30 miles and they have 70 miles of laterals. The top width of one is 24 ft., of the other 16 ft., the depth is 3 ft., grade 2½ ft. or more to the mile, and their combined capacity is 300 cu. ft. per sec. The head-works are designed on a different principle from that of the other canals of Kansas. There is no wing dam but instead, the canal is extended a mile or more up along the river as in the case of an underflow ditch, and the water taken into the canal with a drop, thus giving the canal a "draw" on the river. Into the head of each canal is built a large box, the full width of the canal, which has partitions in the direction of the canal. To the front end of each partition are nailed vertical pieces, forming grooves into which 2-inch planks are dropped horizontally, thus enabling the water to be taken into the canal at any desired height above the bottom of the river. The total cost of these canals and head-works was $35,000. They command an area of 15,000 acres, 2000 of which are said to be at present irrigated.

Irrigation from wells is of recent origin and rapid growth in Western Kansas. Mr. I. L. Diesem of Garden City, who began irrigating from his plant July. 1890. was the first to put in a large pump for this purpose in Finney Co., and so far as I can learn the first in this region. There was one five inch pump in Finney Co. prior to 1890. There are now more than 125 of these plants in this county.

In this method of irrigating it is necessary to pump the water into a reservoir, first, in order to warm the water before applying it to the soil, and second, in order to apply it to the whole area as quickly as possible, thus distributing the water evenly over it, and reducing the evaporation loss. The depth of the reservoir is necessarily small because the bottom of it should be high enough so that the water will flow from it by gravity onto the land, and so that the distance the water is raised, or the power expended, shall be the least possible. The area of the resirvoir will depend on the volume of water the irrigator wishes to have at his command at any one time.

Mr. I. L. Diesem irrigated from his plant 10 acres, most of which is devoted to vegetables. It consists of two reservoirs, one 60x150 ft., the other 80x150 ft., a 14-ft. Halliday windmill on a 35-ft. tower, an 8-inch Gause irrigating pump in a well 8 ft. diameter and 13 ft. deep. The mill makes 32 to 40 revolutions per minute and works on an average 10 hours per day during the irrigating season. The pump makes one 12-inch stroke for each revolution of the wheel. It is connected to five 2-inch pipes which extend down into the water in the well, and to three 1¼-inch well points driven down into the sand in the bottom of the well. The water is raised 17 feet. From the given dimensions we find that from 11.2 to 14 cub. ft. of water is raised per minute and from 11,900 to 14,875 ft. lbs., or from .36 to .45 of a horse power of useful work is done per minute by the windmill.

Mr. D. M. Frost's irrigating plant, near Garden City, is of more recent construction. With it he irrigates 20 acres of vegetables. The water is pumped into a reservoir 100x100 ft. by three pumps worked by two windmills. The largest pump has a 12-inch cylinder, 10-inch stroke, and is attached to a 6-inch sand point driven 36½ ft. into the ground. The water level is 8½ ft. below the surface of the ground, and the distance to the discharge pipe is 5½ ft., hence the water is raised 14 ft. It is worked by a 12 ft. steel "Ideal" windmill and raises 167 gallons of water per minute in a good wind. Each of the other pumps has a 6-inch cylinder, 3-inch supply pipe and 10-inch stroke. The two, worked by an overshot wheel, raise 66 gallons per minute in a good wind.

For raising a comparatively small quantity of water a small distance a windmill is undoubtedly the cheapest motor. A great many of them are in use in Western Kansas and the number is rapidly increasing. Very few experiments have been made on windwills to determine the relation of their parts for maximum effect, or test of their power for different wind velocities. Thousands of water motors have been tested and they have been brought to a high state of efficiency, but the only records of any value of experiments on windmills are those of Smeaton, the great English engineer, on model windmills, published in 1755 to '63, and some observations of windmills made by the French engineer, Coulomb, published in 1821. Some windmill manufacturers claim to have made some experiments on their mills, if so they have not given them to the public. The writer has undertaken experiments and tests of windmills and hopes soon to be able to publish results of value; he will therefore in this paper speak very briefly of this part of the subject, leaving the mathematical investigation and experimental results for another paper.

Steel windmills are rapidly replacing wooden ones, mainly on account of difference in cost. Probably ten times as many steel mills are being sold at the present time as wooden ones. The price of steel has fallen so rapidly the last few years that now steel mills of any diameter can be bought for a good deal less than wooden ones of the same diameter. Steel mills differ from wooden ones in two or three important particulars: first, in the gearing by which the steel wheel revolves two to three times to each stroke of the pump, enabling it to run in a wind of a much less velocity than a wooden one not thus geared; second, in the slats of the steel wheel being curved and larger than those of the wooden one, thus making the wind pressure for a given wind area greater in the former than in the latter, and third, steel wheels have a less wind area than the wooden ones of the same diameter. To illustrate the latter point, the wind area of a "solid" wooden wheel 12 ft. diameter is 105 sq. ft. while the wind area of a steel one of that diameter which the writer measured is only 75.6 sq. ft. That is, the wind area of the wooden wheel is 1.4 times that of the steel one.

The windmill ordinarily used for pumping water for stock is not suited to the pumping of water for irrigation. It is too light and will turn out of the wind for a small wind velocity. A windmill for irrigating purposes should be heavy enough, and so designed that its whole wind area is available for velocities of 30 miles or less per hour; its wind area should not begin to lessen for a velocity under 30 miles per hour. The work which a windmill will do increases as the first-power of the wind area and as the third power of the wind velocity, hence the importance of designing the mill so that it will work at a high wind velocity. It has been shown in table II that the velocity of the wind at Dodge City is 11 miles or more per hour for 54 per cent. of the time during the irrigating season. Probably the velocity is not greater than 30 to 35 miles per hour for more than 4 per cent. of the time, so that a mill properly designed will run at that place 50 per cent. of the time during the irrigating season, the least velocity during the time being 11 miles per hour.

The instructors in the Civil Engineering Department of the University of Kansas, and the writer in particular as instructor in irrigation, will be glad to give to those who may wish it any information on the subject of irrigation or wind motors that they can. They will be pleased to receive short descriptions of new irrigation works in Kansas, or of old ones not mentioned in this paper. These reports will be tabulated as far as possible and a copy sent to each contributor.

# List of Birds of Finney County, Kansas.

BY H. W. MENKE.

Finney county lies in the western and dryer portion of the State. As a matter of course its bird-fauna does not comprise a great number of species, but is made up of an abundance of the few species adapted to the local conditions, and of the stragglers taken during migration. Especially is this fact noticeable in the absence of the arboreal warblers and sparrows and of certain water-birds as breeders. That this may be better understood, the topography of the locality in question should be considered.

The Arkansas river flows through the county from the west, dividing it into two divisions. The portion lying north of the river is the larger. This part, other than the river valley, is chiefly of prairies, the exception being a series of sand-stone bluffs in the southeast corner and a group of sand-hills near the center. The southern division is nearly all sand-hills with little variation. The western half of the river valley is partially wooded with medium-sized cottonwood; while, where water is obtainable, the majority of land-owners have planted groves of fruit and other trees, the rapid growth of which is fast overcoming the chief drawback to an increased variety of birds.

Seasonal rainfall causes considerable fluctuation in the presence of birds. Heavy rains early in the spring fill the prairie lakes and convert more or less of the river-bottom into swamps. Such conditions invite large numbers of water-birds: geese, ducks, snipes, etc., which remain several weeks. On the other hand a lack of rain reverses these conditions with the result of an evident lessening of numbers among certain species and a total absence of others which may have been abundant the previous year. Its western location makes Finney county a favorable place for catching stragglers of those species which have a western range. Three of these I am able to add as new species to the Kansas list. They are:

House Finch (*Carpodicus mexicanus frontalis*), Louisiana Tanager (*Piranga ludoviciana*) and Oregon Robin (*Hesperocichla nævia*). Besides these three of western range I have taken one of eastern range, also new to the state—Black-throated Blue Warbler (*Den-*

*droica cærulescens*). The Warbler was taken the same day as the Oregon Robin.

This list makes no pretention to completeness. A constant watch during the migratory season would probably increase the number to over 200, while a diligent search throughout the breeding season would reveal more summer residents. As it is, the list includes nothing uncertain, embracing only those species which I have personally identified.

American Eared Grebe, *Colymbus nigricollis californicus.* Migratory; common.

Pied-billed Grebe, *Podilymbus podiceps.* Common summer resident.

Franklin's Gull, *Larus franklini,* Occasionally occurs in large flocks in the spring.

Black Tern, *Hydrochelidon nigra surinamensis.* Migratory; irregular. Usually abundant.

American White Pelican, *Pelicanus erythrorhynchas.* Rare visitant.

American Merganser, *Merganser americanus.* Common in migration.

Red-breasted Merganser, *Merganser serrator.* Rare.

Hooded Merganser, *Lophodytes cucullatus.* Rare.

Mallard, *Anas boschas.* Abundant during migration and rare summer resident.

Gadwall, *Anas strepera.* Common migrant.

Widgeon, *Anas americana.* Common migrant.

Green-winged Teal, *Anas carolinensis.* Migratory, abundant.

Blue-winged Teal, *Anas discors,* Migratory; abundant and rare summer resident.

Cinnamon Teal, *Anas cyanoptera.* Rare. One specimen taken by myself.

Shoveler, *Spatula clypeata.* Abundant in migration; occasionally breeds.

Pintail, *Dafila acuta.* Common migrant.

Red-head, *Aythya americana.* Common.

Canvas-back, *Aythya vallisneria.* Rare.

Lesser Scaup, *Aythya affinis.* Common.

Ring-neck Duck, *Aythya collaris.* Rare.

American Golden-eye, *Glaucionetta clangula americana.* Rare in migration.

Buffle-head, *Charitonetta albeola.* Rare.

Ruddy Duck, *Erismatura rubida.* Common.

American White-fronted Goose, *Anser albifrons gambeli.* Rare, two specimens.

Lesser Snow Goose, *Chen hypoborea.* Abundant in migration.

Canada Goose, *Branta canadensis.* Abundant.

American Bittern, *Botaurus lentiginosus.* Common summer resident.

Great Blue Heron, *Ardea herodias.* Common in migration.

Black-crowned Night Heron, *Nycticorax nycticorax nævius.* Rare; one specimen.

Yellow-crowned Night Heron, *Nycticorax violaceus*, one specimen taken September 1st, '94.

Sandhill Crane, *Grus mexicana.* Abundant.

Virginia Rail, *Rallus virginianus.* Common summer resident in rainy seasons.

Sora Rail, *Porzana carolina.* In migration common. Rare summer resident.

Black Rail, *Porzana jamaicensis.* Rare summer resident. My brother, G. G. Menke, found a set of nine eggs of this species, June 6th, 1889.

American Coot, *Fulica americana.* An abundant migrant and common summer resident.

Wilson's Phalarope, *Phalaropus tricolor.* Abundant in migration. Although I have observed the bird in all summer months, I know of no instance of its breeding in the county.

American Avocet, *Recurvirostra americana.* Abundant in migration and rare summer resident.

Black-necked Stilt, *Himantopus mexicanus.* Shot one specimen the 16th day of May, 1892, and saw six more the 13th of following month.

Wilson's Snipe, *Gallinago delicata.* Common migrant.

Long-billed Dowitcher, *Macrorhampus scolopaceus.* Not common.

Stilt Sandpiper, *Micropalama himantopus.* Rare.

Baird's Sandpiper, *Tringa bairdi.* Migratory; abundant.

Least Sandpiper, *Tringa minutilla.* Migratory; abundant.

Semipalmated Sandpiper, *Ereunetes pusillus.* Common during migration.

Marbled Godwit, *Limosa fedoa.* One specimen taken.

Greater Yellow-legs, *Totanus melanoleucus.* Migratory; common.

Yellow-legs, *Totanus flavipes.* Abundant in migration,

Solitary Sandpiper, *Totanus solitarius.* Rare.

Green Sandpiper, *Totanus ochropus.* Rare.

Willett, *Symphemia semipalmata.* Rare.

Bartramian Sandpiper, *Bartramia longicauda.* Common summer resident and abundant in migration.

Spotted Sandpiper, *Actilis macularia.* Rare.

Long-billed Curlew, *Numenius longirostris.* Occasionally met with in small flocks during migration.

Black-bellied Plover, *Charadrius squatarola.* Rare. A specimen shot from a flock of eight the 17th of May, 1890; another shot April 27th, 1893.

Killdeer, *Ægialitis vocifera.* Abundant summer resident.

Mountain Plover, *Ægialitis montana.* Abundant summer resident.

Bob-white, *Colinus virginianus.* Comparatively abundant since the introduction of six dozen in 1891.

Prairie Hen, *Tympanuchus americanus.* Abundant.

Mourning Dove, *Zenaidura macroura.* Abundant.

Turkey Vulture, *Cathartes aura.* Common.

Marsh Hawk, *Circus hudsonicus.* Common.

Cooper's Hawk, *Accipiter cooperi.* Not common.

Red-tailed Hawk, *Buteo borealis.* Rare.

Swainson's Hawk, *Buteo swainsoni.* Abundant in migration and common resident.

American Rough-legged Hawk, *Archibuteo lagopus sancti-johannis.* Common winter resident.

Ferruginous Rough-leg, *Archibuteo ferrugineus.* Rare.

Golden Eagle, *Aquila chrysaëtos.* Rare.

Bald Eagle, *Haliæetus leucocephalus.* Rare.

Prairie Falcon, *Falco mexicanus.* Common winter resident.

Pigeon Hawk, *Falco columbianus.* Rare winter resident.

Richardson's Merlin, *Falco richardsoni.* Common winter resident.

American Sparrow Hawk, *Falco sparverius.* Abundant in migration.

American Osprey, *Pandion haliætus carolinensis.* Rare visitant.

American Long-eared Owl, *Asio wilsonianus.* Common.

Short-eared Owl, *Asio accipitrinus.* Plentiful; resident.

Saw-whet Owl, *Nyctala acadica.* Rare winter visitant. Two specimens.

Great Horned Owl, *Bubo virginianus.* Rare.

Snowy Owl, *Nyctea nyctea.* Rare winter visitant.

Burrowing Owl, *Speotyto cunicularia hypogæa.* Abundant. I do not think this species winters in this locality as I have never observed it earlier than the first of March or later than the first of November.

Yellow-billed Cuckoo, *Coccyzus americanus.* Common summer resident.

Black-billed Cuckoo, *Coccyzus erythrophthalmus.* Rare summer resident.

Belted Kingfisher, *Ceryle alcyon.* Rare summer resident.

Downy Woodpecker, *Dryobates pubescens.* Rare winter visitant.

Red-headed Woodpecker, *Melanerpes erythrocephalus.* Common summer resident.

Lewis' Woodpecker, *Melanerpes torquatus.* One specimen, April 23rd, 1893.

Flicker, *Colaptes auratus.* Abundant in migration.

Red-shafted Flicker, *Colaptes cafer.* Abundant in migration and common winter resident.

Whip-poor-will, *Androstomus vociferus.* Rare summer visitant. Two specimens.

Western Nighthawk, *Chordeiles virginianus henryi.* Abundant summer resident.

Ruby-throated Hummingbird, *Trochilus colubris.* Rare spring visitant.

Scissor-tailed Flycatcher, *Milvulus forficatus.* Rare summer resident.

Kingbird, *Tyrannus tyrannus.* Common; summer resident.

Say's Phoebe, *Sayornis saya.* Common in migration.

Olive-sided Flycatcher, *Contopus borealis.* Rare.

Traill's Flycatcher, *Empidonax pusillus traillí.* Rare.

Prairie Horned Lark, *Otocoris alpestris praticola.* Abundant; resident.

Desert Horned Lark, *Otocoris alpestris arenicola.* Common; resident.

American Magpie, *Pica pica hudsonica,* Rare winter visitant.

Blue Jay, *Cyanicitta cristata.* Common summer resident.

American Crow, *Corvus americanus.* Common; migratory.

Clark's Nutcracker, *Picicorvus columbianus.* Shot one and saw two others the 10th of October, 1891.

Pinon Jay, *Cyanocephalus cyanocephalus.* This species has not been noted since the fall of 1891. Up to that time the Pinon Jay was a common winter resident, and in the falls of '89, '90, and '91, appeared in large flocks.

Bobolink, *Dolichonyx oryzivorus.* One specimen noted May 27th, 1892.

Cowbird, *Molothrus ater.* Common.

Yellow-headed Blackbird, *Xanthocephalus xanthocephalus.* Migratory; common.

Red-winged Blackbird, *Agelaius phœniceus.* Abundant.

Western Meadowlark, *Sturnella magna neglecta.* Resident; abundant.

Baltimore Oriole, *Icterus galbula.* Rare summer resident.

Brewer's Blackbird, *Scolecophagus cyanocephalus.* Migratory; common.

House Finch, *Carpodicus mexicanus frontalis*. In regard to this first known appearance of the House Finch in Kansas, I shot five from a flock of fifteen. January 5th, 1882. Visiting the same vicinity the following day I secured another from the remnant of the flock, and on the 7th still another. The place frequented by the finches was a group of alfalfa stacks in a large field of the same.

American Crossbill, *Loxia curvirostra minor*. Five specimens secured October 23rd, 1891, by G. G. Menke.

Mexican Crossbill, *Loxia curvirostra stricklandi*. Shot three from a small flock December 7th, 1891, and from that date until the last of February, '92, I observed several small flocks and secured a number of specimens.

American Goldfinch, *Spinus tristis*. Migratory; abundant.

Pine Siskin, *Spinus pinus*. Winter visitant; rare.

Chestnut-collared Longspur, *Calcarius ornatus*. Winter resident; abundant.

McCown's Longspur, *Rhynchophanes maccownii*. Winter resident; abundant.

Vesper Sparrow, *Poocætes gramineus*, Common in migration.

Savanna Sparrow, *Ammodramus sandwichensis savanna*. Winter resident; rare.

Grasshopper Sparrow, *Ammodramus savannarum passerinus*. Resident; common.

Lark Sparrow, *Chondestes grammacus*. Summer resident; common.

Harris' Sparrow, *Zonotrichia querula*. One shot and two noted May 9th, 1892.

White-crowned Sparrow, *Zonotrichia leucophrys*. Winter resident; common.

Tree Sparrow, *Spizella monticola*. Winter resident; adundant.

Chipping Sparrow, *Spizella socialis*. Migratòry; abundant.

Slate-colored Junco, *Junco hyemalis*. Winter resident; abundant.

Song Sparrow, *Melospiza fasciata*. Winter resident; Not common.

Towhee, *Pipilio erythrophthalmus*. Migratory; common.

Black-headed Grosbeak, *Hobia melanocephala*. Rare summer resident.

Blue Grosbeak, *Guiraca cærulea*. Summer resident; Common.

Indigo Bunting, *Passerina cyanea*. Summer resident; rare.

Lazuli Bunting *Passerina amœna*. Common summer resident.

Dickcissel, *Spiza americana*. Abundant summer resident.

Lark Bunting, *Calamospiza melanocorys*. Summer resident; abundant.

Louisiana Tanager, *Piranga ludoviciana*. Shot one male of this

species May 20th, 1893. June 1st, '93, I shot another and observed several pairs in a cottonwood grove, 4½ miles west of Kendall, Kearney county.

Purple Martin, *Progne subis*. Common summer resident.

Cliff Swallow, *Petrochelidon lunifrons*. Common.

Barn Swallow, *Chelidon erythrogaster*. Abundant.

Cedar Waxwing, *Ampelis cedrorum*. Occasional summer visitant.

Northern Shrike, *Lanius borealis*. Common winter resident.

White-rumped Shrike, *Lanius ludovicianus excubitorides*. Summer resident; common.

Red-eyed Vireo, *Vireo olivaceus*. Migratory; not common.

Black and White Warbler, *Mniotilta varia*. One specimen taken.

Yellow Warbler, *Dendroica æstiva*. Summer resident; abundant.

Black-throated Blue Warbler, *Dendroica cærulescens*. Captured a fine male in a deserted farm house, October 17th, 1891.

Myrtle Warbler, *Dendroica coronata*. Migratory; common.

Audubon's Warbler, *Dendroica auduboni*. Migratory; common.

Black-poll Warbler, *Dendroica striata*. Migratory; not common.

Oven-bird, *Seiurus aurocapillas*. Common in migration.

Maryland Yellow-throat, *Geothlypis trichas*. Two specimens.

Yellow-breasted Chat, *Icteria virens*. Summer resident; common.

Wilson's Warbler, *Sylvania pusilla*. One specimen.

American Pipit, *Authus pennsylvanicus*. Common in migration.

Mockingbird, *Mimus polyglottos*. Summer resident; plentiful.

Catbird, *Galeoscoptes carolinensis*. Common in migration.

Brown Thrasher, *Harporhynchus rufus*. Common in migration.

Rock Wren, *Salpinctes obsoletus*. Resident; not common.

House Wren; *Troglodytes ædon*. Rare summer resident.

Long-billed Marsh Wren, *Cistothorus palustris*. Summer resident; not common.

Ruby-crowned Kinglet, *Regulus calendula*. Common in migration.

Townsend's Soltaire, *Myadestes townsendi*. Rare.

Hermit Thrush, *Turdus aonalaschkæ pallasi*. Migratory; not common.

American Robin, *Merula migratoria*. Migratory; abundant.

Varied Thrush, *Hesperocichla nævia*. One specimen; shot by myself October 17th, 1891.

Bluebird, *Sialia sialis*. Resident; common.

Mountain Bluebird, *Sialia arctica*. Saw a flock of four February 22nd, 1893, and shot one from a flock of five March 13th.

English Sparrow, *Passer domesticus*. Resident; and I am sorry to say abundant.

# A Study of the Prothorax of Butterflies.

BY MAY H. WELLMAN.

The prothorax, as it bears no wings and hence need not like the meso- and metathorax, give space to a great muscular development, is reduced to a narrow collar. The sclerites of the dorsum and pleura are more or less fused, or some of them may be wanting entirely; but the sclerites present may, usually without much difficulty, be homologized with those of the more developed meso- and meta-thoracic segments. Throughout the families of the Lepidoptera the prothoracic structure and development are, within certain limits, uniform, but within those limits is found considerable variation with respect to the development of certain sclerites, especially those of the dorsum, where are found the prominent "prothoracic lobes" of Scudder and the median chitenized sclerite homologous with the scutellum of the other thoracic segments.

The prothorax has much greater freedom of movement than the other segments. This is due to the flexibility of the membrane uniting it with the meso-thorax and with the head and which even largely comprises the body wall of the segment.

The membrane surrounds the strongly chitenized sclerites, except where the median scutellum joins the narrow anterior and posterior chitenized bands which articulate with the head and mesothorax. All the parts of the prothorax are closely beset with scales varying in size and abundance in the different groups.

The dorsal aspect of the prothorax of *Danais archippus*, fig. I, and a side view of *Pieris rapæ*, fig. II, show all the parts of a typical prothorax.

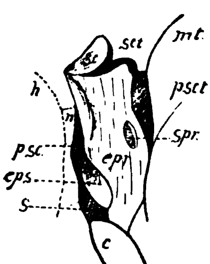


*fig. I.*

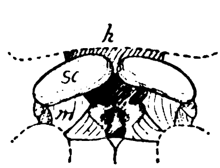


*fig. II.*

The "prothoracic lobes," the best known parts because the most conspicuous, vary greatly in the different groups, from the thin

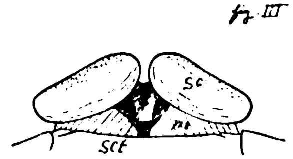
scale-like lobe and the broad coalesced collar of some of the moths to the forms in Papilionidæ where the lobes are entirely wanting. The scutellum also shows great diversity in form, though a steady development may be traced from the mere dot, scarcely chitenized, found in the familes of Noctoidæ, to the higher groups of butterflies, where the chitenized sclerite forms the most conspicuous part of the prothorax.

The width of the prothorax is noticeably varied, some groups showing a very narrow, compact form with very little membrane, others again being loosely articulated and showing a broad membranous surface between the lobes and the mesothorax.

This variation of form in the sclerites of the prothorax may be reduced to certain families. In the following notes these types are presented and a simple grouping of the species examined is made, based on the different forms of the prothorax found; these types are arranged into groups or classes.

The first class is based on the special development of the dorsal lobes which almost fill the dorsal space between the head and mesothorax. The second group is characterized by a greater development of the scutellum. In the third group the prothorax is very narrow and the parts inconspicuous. The fourth class is characterized by scale-like lobes. Under each of these groups a few characteristic species are presented.

fig III




The first group is well represented by *Grapta interrogationis* (fig. III). A narrow membranous neck separates the head from the prothorax; the scutum and scutellum are present, the former in the shape of the two large terminal lobes which almost fill the dorsal space, nearly concealing the triangular crescent-shaped scutellum. The lobes are dark brown in color, hollow, the upper surface consisting only of a thin shell; they are covered with short velvety scales, the punctulations, or scale insertions, showing plainly when the scales are brushed away; the anterior part of the scutellum extends forward, forming the deep cleft between the lobes and then expanding into a narrow chitenized band which forms the anterior margin of the prothorax, and corresponds to the proscutum. The lateral extremities of the scutellum extend into slender supporting braces beneath the lobes; the scutellum is slightly raised above the membranous surface; it is very narrow just in front of the mesothorax, then broadens abruptly into a narrow collar which articulates with the mesothorax. This articulating part is generally concealed by the overlapping meso-

thorax and is probably homologous with the postscutellum of the other segments. The parts of the pleura and sternum are plainly differentiated; the sternum and episternum forming a broad band beneath; the episternum reaches to the lower edge of the dorsal lobes. The suture between the sternum and episternum, while not distinct is yet evident, the upper part of the episternum is somewhat tumid, resembling the dorsal lobes in shape and surface. That part of the membrane lying just above the coxæ is partially chitenized in this form and corresponds to the epimeron of the other thoracic segments. When one examines the form of the epimeron in the wing-bearing segment there is no doubt that the membranous part of the prothorax, lying between the other sclerites and the mesothorax is homologous with the epimeron, for that sclerite is always only partially chitenized or, at most, always lies adjacent to the area of delicate membrane surrounding the wing articulation. See fig. II.

The next group shows a considerable variation in the structure of the lobes and so may be arranged into three subclasses. The general appearance, however, is much the same throughout, the prothorax being characterized by the broad membranous part which joins, unbroken, with the membrane surrounding the wing of the mesothorax, that part next the wing being covered by the patagia of the mesothorax.

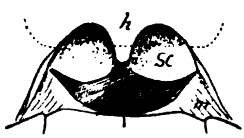


fig IV

The first subclass of this group is represented by *Colias cæronia*, fig. IV. The prothoracic lobes are small and are situated on the extreme lateral border of the prothorax. They are very dark in color and show fine tuberculations. The membranous part of the prothorax drops away abruptly from the lobes and scutellum, thus leaving them prominent; the membrane attached to the lateral extremity of the lobes rolls backward slightly along the anterior margin of the prothorax, forming a narrow ridge beneath the lobes, and in front of this fold is the narrow chitenized band or collar formed by a lateral extension of the scutellum which it joins between the lobes. The sternum and episternum are coalesced into a narrow band which does not reach the dorsal area by some distance; this is one of the important characteristics which separate this group from the preceding, and holds throughout the three subclasses with only slight variations in form. The sternum meets the anterior chitenized band of the dorsum about midway on the pluræ, so completing the chitenized ring which gives strength and form to the prothorax.


fig V

The next subclass is represented by *Papilio eurymedon* (fig. V), in which the lobes are entirely wanting, the entire dorsal surface of the prothorax except the median scutellum being of a membranous character. The prothorax is broader than that of *Colias*, and the scutellum larger, of more complicated form and very prominent. The prothorax is deeply cleft in front by the narrow portion of the scutellum at its juncture with the chitenized collar; just back of the cleft this narrow neck widens abruptly into the broad, deeply fork-shaped scutellum, which is raised prominently above the rest of the prothorax.

The sternum differs from that of *Colias* in having a second narrower band lying just anterior to the first. The two are coalesced at the junction with the dorsal band, the point being marked by a small tumid lobe.

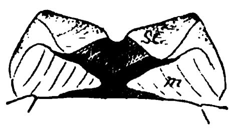



fig VI

The last subclass is represented by *Pieris rapæ*, fig. VI. The prothorax is not as broad as in the preceding. There are no lobes, but the spaces occupied by the lobes in other forms is here represented by two triangular concave surfaces, unchitenized and yellowish white in color, and showing the insertion of the scales. The lateral extremities, which project cephalad slightly, are apparently partially chitenized and are much darker in color. The median cleft between these two surfaces is broader than in the others described and the broad triangular scutellum joins smoothly with the chitenized band in front. The general shape of the prothorax is that of *Colias cæronia* with the exception of the lobes, the membrane rolling back slightly along the front in the same manner. The articulating band just beneath the anterior margin of the mesothorax is rather broader than in the others described and more noticeable.

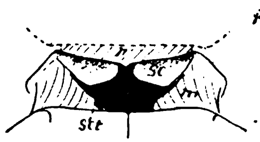
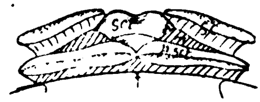



fig VII.

*Lycænidæ*, fig. VII. In this group the prothorax is very small, there are no lobes, only the narrow concave surfaces, very much as in *Pieris*. These surfaces are so placed that the anterior margin is much lower than the posterior, thus throwing the flattened surfaces so that they lie in an almost vertical position. The scutellum is very narrow but its slender lateral extremities extend almost across the dorsal surface of the prothorax. The narrowed portion of the scutellum and the sclerites articulating with the mesothorax are entirely concealed. The prothorax is closely set with broad scales. The sternum and episternum are coalesced,

forming a broad band above the coxæ. A portion of the ventral part of the sternum is almost vertical; it is densely set with broad scales and the head fits closely against it. The episternum becomes narrower on the sides until it coalesces with the proscutum and is concealed by the overlapping membrane.

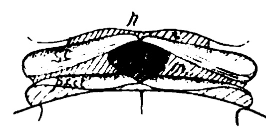



h VIII

*Eudamus tityrus* is a typical species of the last group. The prothorax is broader than in the *Lycænidæ* but not as prominent as in the other groups. The lobes are upright, much compressed, almost scale-like in appearance, and fold back over the rest of the prothorax. They are light colored and consist of two thin upright walls arising from a narrow base. They are somewhat broader at the apex than at the base. The two lobes are widely separated by the scutellum which occupies about a third of the dorsal space. The scutellum is triangular in shape, light brown in color, and is divided by a median furrow into two slightly tumid lobes; the scutellum does not extend caudad beneath the mesothorax but terminates as two lobe-like sclerites which are very narrow but extend across the whole dorsal surface just in front of the mesothorax; they have a slight median ridge and are finely punctulated. Back of these lobes the prothorax presents a simple membranous appearance; the narrow spaces between the two sets of lobes, is also of a simple membranous character. The sternum is cresent-shaped but with a narrow posterior projection between the coxæ. The suture between the sternum and episternum is very evident, the episternum appearing as a tumid oval sclerite reaching well up on the dorsum.

The scales covering the prothorax are very large and fan-like, nearly as large as the scale-like lobes, and are set so closely together as to make it almost impossible to remove them without removing the scales with them.

There is but little variation in this last group and it shows throughout a marked likeness to the prothorax of some of the moths, especially to the *Sphingidæ*.




h IX

The sphinx moth, *Hemaris*, fig. IX, has the frontal lobes delicate and scale-like, the scutellum small, triangular and only slightly raised above the membranous part; it does not separate the lobes as widely as in *Eudamus tityrus* the second set of lobes differ from those in *Eudamus* in being almost as high as the frontal lobes and of the same scale-like character; the space between the two sets of lobes is much narrower than in *Eudamus*. The sternum and episternum present the same structure, the episternum is larger and extends below the suture between it and the sternum.

Without any reference to the accepted classification of families, a simple tabulation of the few species examined is added, based purely on these variations in the structure of the prothorax. The grouping coincides in the main with the general classification. The Papilionidæ, however, show the most striking variations. In Nymphalidæ, the sub-family Heliconidæ comes nearer to the Papilionidæ than the other groups. Of the species in Lycænidæ and Hesperidæ examined there is reasonable uniformity of structure.

CLASS I. Nymphalidæ.

Grapta interrogationis.
Danais archippus.
Pyrameis atalanta.
Pyrameis huntera.
Argynnis aphrodite.
Argynnis cybele.
Argynnis helena.
Euptoieta claudia.
Vanessa antiopa.
Anæa andria.
Satyrus alope.
Limenitis ursula.

CLASS II. (Papilionidæ)

SUB A.

Colias cæsonia.
Terias sp.
Colias hecla.
Nathalis iole.
Terias lisa.

SUB B.

Papilio eurymedon.
Papilio asterias.
Parnassius smintheus.

SUB C.

Pieris rapæ.

CLASS III. (Lycænidæ.)

Chrysophanus virginiensis.
Thecla sp. (exotic).
Lemonias nais.
Lycæna (a).
Lycæna (b).

CLASS IV. (Hesperidæ)

Pamphila zebulon.
Pyrgus tessellata.
Eudamus tityrus.
Eudamus bathyllus.

# American Platypezidæ.

BY W. A. SNOW.

(With Plate 12.)

During the summer of 1894 the University of Kansas sent out five different collecting parties for the purpose of gathering specimens for its museum. One of these in charge of Prof. F. H. Snow devoted the entire time spent in the field—about five weeks—to the collecting of insects. The other members of this party were Messrs. Hugo Kahl, E. C. Case, H. W. Menke, the writer and his young brother. Four weeks were spent in camp in the Magdalena Mountains, Socorro Co., N. M. The camp was situated in Hop Canyon. Nearly all of the 12,000 specimens obtained on the trip were taken in this canyon. The elevation of the camp was 7,500 feet; of the the head of the canyon, 9,000; of the highest mountain in the range, 9,900 feet.

The collections made at this place were rich in diptera, including many representatives of the rarely occurring family Platypezidæ. No less than seven species belonging to this family were obtained, six of which are described below as new.

The four genera belonging to Platypezidæ are *Platypeza* Meig., *Callomyia* Meig., *Opetia* Meig., and *Platycnema* Zett.; separated by Schiner as follows:

1. Discal cell present........................................2
   Discal cell absent.........................................3
2. Fourth longitudinal vein simple ................CALLOMYIA.
   Fourth vein forked.............................PLATYPEZA.
3. Fourth longitudinal vein simple................PLATYCNEMA.
   Fourth vein forked................................OPETIA.

Townsend has recently described* a Platypezid from Illinois, having irregular and greatly enlarged hind tarsal joints (P. 12, fig. 2) and erected therefor the genus *Calotarsa*, the type of which is now in the University of Kansas collection. In my opinion *Calotarsa* must be rejected. It is nothing more than a large and

*Canadian Entomologist, Vol. XXVI, p. 50. *Calotarsa ornatipes* first described as an anomalous Syrphid and afterwards maintained as a valid genus of Platypezidæ (l. c., p. 102).

handsome *Platypeza*, to which it has been referred by Nathan Banks,* Williston,† Aldrich (*in litt.*) and Coquillett.‡ To quote from Prof. Townsend's second paper on *Calotarsa*: "As to the validity of the genus, it is, barring the neuration, quite as unique as before supposed. It is much larger than any known Platypezidæ, which range from 1½ to 3 mm., or at most 4 mm., and its color is quite different from what is usual in that family. It does not agree in the structure of its hind legs with *Platypeza*, to which genus it most nearly approaches in venation. In *Platypeza* the femora, tibiæ and tarsi are evenly widened and thickened in the hind legs. In *Calotarsa* the hind femora and tibiæ are hardly at all widened or thickened, while the tarsi are greatly widened, flattened and winged. It is also removed from *Platypeza* s. str. in certain neurational and antennal characters for which see description, and in the prominent hypopygium."

Considering these points seriatim, that of size is unimportant. *Ornatipes* is 5½ mm., *velutina* reaches 4 mm.; *venusta* n. sp. sometimes exceeds 4 mm.; *calceata* n. sp. varies from 4 to 6 mm. As to coloration, *ornatipes* is very similar to *calceata* (Pl. 12, figs. 1 and 3) and not unlike *pulchra* n. sp. whose male does not possess the extreme tarsal development of the two former. Differences in coloration must seem of insignificant generic import in Platypezidæ when we remember the sexual variations in this respect exhibited by such species as *Callomyia amœna*, and *C. leptiformis*. In *ornatipes* the hind legs are most certainly widened and thickened, but not in proportion to the enormous enlargement of the tarsal joints. The same may be said about the allied species *calceata*. The "certain neurational and antennal characters" which remove *ornatipes* from *Platypeza* I have failed to find. Lastly the hypopygium shows no distinctive character, as a comparison with other species of the genus will show.

In 1860 Loew described§ two African Platypezidæ and stated that they were the first known extra-European members of the family. Schiner in 1862 gave a list|| of thirty-one European species. In 1865 Loew described** seven species from America. In 1868 Schiner gave 39 as the number of species of Platypezidæ known from the whole world.†† Three more American species were added by Loew in 1869.‡‡ From 1869 to 1892 I do not find any additional

*L. c., p. 88.
†L. c., p. 113.
‡L. c., p. 102.
§Diptera of South Africa, p. 285.
||Fauna Austriaca, Vol. 1, p. 239-243.
**Diptera Americæ Septentrionalis Indigena, Century VI. Nos. 76-82.
††Novara Expedition, Diptera, p. V, note.
‡‡L. c., Century IX. Nos. 81-83.

species recorded. In the latter year Dr. Williston described a *Callomyia* from Mexico.* Townsend's species (l. c. 1894) completes the list, making a total of 44 species hitherto known, to which number eight are added below.

Of the twelve American species hitherto described but one is distinctly western, namely: *Callomyia bella* Will. from Mexico, the others are from New Hampshire, New York, Pennsylvania, District of Columbia and Illinois. To this list of American habitats may be added Kansas and New Mexico.

The following tables of the American species of *Platypeza* are constructed partially from descriptions, as Loew's species *flavicornis pallipes*, *obscura* and *anthrax* are unknown to the writer.

## PLATYPEZA.

### TABLE OF SPECIES—MALES.

1. Hind tarsi remarkably exaggerated and elaborate; first joint with long setaceous clubbed appendage.............. 2
   Hind tarsi somewhat enlarged as usual and without such appendage........................................ 3
2. Fourth tarsal joint much larger than any other.......*ornatipes.*
   Second tarsal joint the largest......................*calceata.*
3. Antennæ yellow; abdomen velvety black..........*flavicornis.*
   Antennæ black........................................ 4
4. Prevailing color velvety black......................... 5
   Thorax cinereous; second and third adominal segments pallid, fourth and fifth black...................*pulchra.*
5. Abdomen except last segment velvety black, without cinereous markings.......................*velutina*, *anthrax*.
   Abdominal segments three to five black, immaculate; second segment with broadly interrupted cinereous band, *umbrosa.*

### TABLE OF SPECIES—FEMALES.

1. Antennæ, first two joints at least, yellow or lutescent...... 2
   Antennæ black........................................ 4
2. Abdomen yellowish brown, cinereous posteriorly, with black bands enlarged in middle......................*calceata.*
   Abdomen cinereous with black bands.................... 3
3. Legs lutescent; sides of first abdominal segment lutescent, *pallipes.*
   Legs infuscate, hind legs fuscous brown; sides of first abdominal segment cinereous..................*tæniata.*
4. Velvety black species................................ 5
   Cinereous species with black abdominal cross bands....... 6

*Biologia Centrali-Americana. Diptera, Vol. III. p. 89.

5. Abdomen black, immaculate ...................... *velutina*.
Abdomen black, segments two to five with anterior angles cinereous ................................. *obscura*.
6. Distal end of discal cell nearly touching border of wing, *cinerea*.
Distal end of discal cell far from border of wing... *egregia*.

**Platypeza calceata n. sp.**—Pl. 12, figs. 1 and 3.

Male. Cinereous. Head concolorous; antennæ, probocsis and palpi yellow, third joint of former infuscate distally, arista black; sides of face, cheeks, and vertex with glistening yellowish pile, turning to red near ocelli. Thorax with four dark brown stripes, the median pair contiguous, the outside pair abbreviated anteriorly, as broad as the middle ones together. Scutellum on disk a little brownish, on posterior border with about eight strong black bristles. Abdomen yellowish-brown; first segment obscurely yellowish, a little black on sides posteriorly and brightly yellow on sides in front; second, third and fourth segments yellowish-brown, with a black or fuscous-black ⊥-shaped spot in center of each, the cross bar of which lies along the incisure and is often deeper black than the upright; sometimes the black extends along the anterior border of the segment, thus: I; often the black of the upright broadens out posteriorly; segments five and six cinereo-fuscous; sides of abdomen with long silky whitish pile, turning to red posteriorly; the narrow ventral surface orange-yellow, more whitish basally. Legs yellowish; hind femora on outer side fuscous, except extreme tip and basal third, on inner side subinfuscate distally and with shining black stripe extending from the tip for about a third the length of femora; hind tarsal joints wonderfully enlarged and grotesquely developed (Pl. 12, fig. 1); first joint transverse on upper side, with a long setaceous black appendage ending in a round flat knob; second joint black, obliquely transverse, and extends upward with parallel sides for some distance forming the handle of an immense saucer-like appendage, the concavity of which is toward the outside, and the surface scattered over with numerous round whitish semi-transparents pots, three or four of these being much larger than the others; third and fourth joints black and much alike in shape but differing in size, the third the largest of the two, both flattened and emitting distally on their upper sides a thin flat prolongation about the length of the main portion of the joint; last joint small, thinly compressed, triangular. Front and middle femora with sparse, long, silky, yellowish pile on outside; hind femora with thin, yellowish pile on inside and a bunch of black pile on outside about a third of distance from base; tip of hind tibiæ and first, second, third and to some extent the fourth of

the hind tarsal joints on inner side with short, thick golden pile. Halteres with yellow stem and fuscous brown knob. Wings hyaline, slightly infuscate near the tip, stigma yellowish; auxiliary vein ends far beyond the anterior crossvein; posterior crossvein close to border of wing, distant on fifth vein one-third to two-thirds its length; second posterior cell long; posterior branch of fourth vein short.

Female. A single female specimen caught at the same time with a male shows slight differences in the coloration of the abdomen; first segment covered with a lightish, somewhat yellowish pollen, and shows but a mere trace of black along the incisure; second segment anteriorly with similar pollen and with a large black triangle arising posteriorly and not reaching the anterior border of segment; third, fourth and fifth segments with smaller similar triangles, elsewhere with cinereous pollen, which covers nearly the whole of the fifth segment, and quite the whole of following segments; sides of first and second segments with soft, silky yellowish pile; sides of following segments with coarser short black pile. Legs yellow except a preapical fuscous spot on hind femora and the blackish hind tarsi (Pl. 12, fig. 3); the hind tarsi are much smaller and present the same type of structure noticed in other females of the genus (see plate); the joints on their inner side furnished with short, brush-like, golden pile as in the male; the long light-colored femoral pile noticed on the male is absent, as well as the tuft of black pile on the hind femora in that sex.

Length of male 4 to 6 mm.; of female 4 mm.

Seventy-five males and one female, Hop Canyon, Magdalena Mts., N. M., 8,000 feet. Nearly all were taken from August 19th to 21st. These strange insects were found dodging and soaring in the air in assemblages of, say, a dozen individuals each, all males. None were caught outside an area of about an acre. They grouped themselves in midair under the overhanging boughs of some large spruce, and when an attack was made upon them with the collecting net they would dodge and scatter, to resume their zig-zag flight a little higher up. The collectors were often obliged to mount a stump or to splice a branch to the net handles to give the nets higher sweep. In flight these insects allow their hind feet to hang heavily downward and look as if they were carrying some heavy burden. Only the merest accident brought the female to net. The writer was watching an inaccessible group of males in the air when an apparently large and black object slowly passed within an inch or two of his eye. A lucky stroke of the net and the thing was found to be no larger nor blacker than a pair of small brown flies. This species was found only in the warmer portions of the day. Three or four days after they were first discovered they apparently disappeared.

I see no reason why *calceata* should not find place in *Platypeza* as it seems to diverge from the species of that genus only in the structure of the masculine hind tarsi. The female is purely typical of *Platypeza*.

The purpose of the elaborate tarsi of *Platypeza ornatipes* and *P. calceata* is doubtless one of adornment.

**Platypeza velutina** Loew.—Pl. 12, fig. 8.

Male. Velvety black. Head black; antennæ concolorous; face except in middle, and cheeks with black pile. Thorax black, opaque, in some lights more fuscous-black. Abdomen velvety-black, last segment and very narrowly on the incisures, obscurely cinereous; sides with long black pile. Legs black, sometimes more fuscous, knees a little brownish; of the hind tarsal joints the metatarsus is broadest, the third joint longest. Halteres black. Wings with a very slight yellowish tinge, veins black; posterior crossvein very near border of wing; first basal cell a little shorter than second costal cell; second posterior cell rather long.

Length 2½ to 3½ mm.

Five specimens, Hop Canyon, Magdalena Mts., N. M., 7,500-8,000 feet, August; and one specimen from Beverly, Mass., August 27th, '68, all males. I see no appreciable difference between the eastern specimen and the western ones.

The above description differs from Loew's in that in the latter the abdomen is "immaculatum" and the wings are "purissime hyalinæ." It is probable that the first is a sexual difference. Loew described a female.

**Platypeza umbrosa** n. sp.—Pl. 12, fig. 7.

Male. Black, cinereous. Head cinereous; antennæ black with slight hoary pubescence; proboscis pallid; occiput black, opaque. Thorax cinereo-fuscous-black, along the median line with a narrow lighter stripe. Abdomen velvety black; hind border of first segment, two large lateral spots of second and all of sixth except the anterior margin, cinereous. Pile of abdomen long, glistening, yellowish, darker posteriorly, thickest near base on sides; pile of sixth segment more bristle-like, black on sides and reddish on end of segment; often this bristle-like, dark pile begins on fifth segment. Legs sublutescent; femora fuscous except at immediate base and tip; last two or three tarsal joints and hind tibiæ infuscate; hind metatarsi longer and wider than following joints (Pl. 12, fig. 7.—the femur is foreshortened in the drawing). Halteres yellowish. Wings broad, slightly incinereate; second costal cell very long and broad, about twice as long as first basal cell; posterior crossvein removed from border of wing (on fifth vein) by a distance distinctly greater than

the length of the second posterior cell; anterior branch of fourth vein well arcuated, comparatively short; posterior branch very long, almost touching wing margin.

Length 2½ to 3½ mm.

Nineteen specimens, Hop Canyon, Magdalena Mts., N. M.; 7,500-8,500 feet; August. Found mostly near where *P. calceata* abounded. They were not observed to hover in the air as was *calceata* but they dodged about with ordinary flight near a small spruce tree. Nearly all were taken on a single day. A few were caught as they ran about on leaves.

**Platypeza tæniata n. sp.**

Female. Cinereo-fuscous. Basal joints of antennæ yellowish; proboscis lutescent; humeri brownish. Abdomen grey with posterior opaque fuscous or black cross bands on segments two-five; the black occupies nearly the whole of second segment, on the following segments the grey prevails; sides of bands parallel—bands not widened in middle. Legs brown, hind pair fuscous; hind tarsi in general resembling figs. 3, 4, Pl. 12, with wide shallow fossa on outside of joints three and four; second joint very short, obliquely transverse, longer on upper side than on under side, third joint longer than first two together. Halteres pale yellow, almost white in described specimen. Wings hyaline, veins brownish; first basal cell of same length as second costal cell; posterior crossvein nearly touching border of wing; posterior branch of fourth vein short.

Length 3 mm.

One specimen, Illinois, Professor Forbes; No. 5689.

Must be near *P. boletina* of Europe,* whose black abdominal bands are widened in their middle.

**Platypeza pulchra n. sp.**—Pl. 12, fig. 6.

Male. Black, cinereous. Face, front, and antennæ concolorous; proboscis lutescent; occiput velvety black. Humeral callosities sublutescent; dorsum with two obscure fuscous stripes. First segment of abdomen opaque black anteriorly, buff posteriorly; second and third segments buff with narrow median black stripe; fourth and fifth segments velvety black; sixth segment grey; incisures between fourth, fifth and sixth segments narrowly pallid on the sides; the third segment may have a lateral fuscous spot; long pile on sides of abdomen glistening yellowish except on segments five and six, where it is black; venter buff. Legs subinfuscate-lutescent, a little cinereous; immediate base and tip of femora lutescent; four front tibiæ and tarsi hardly infuscate except on distal joints of latter; first joint of hind

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* Shiner, Fauna Austrica, Vol. I, p. 241.

tarsus a little longer and wider than any following joint. Halteres luteous. Wings broad, lightly tinged with yellowish, veins fuscous; first and third basal cells subequal, very short, about one-half length of second costal cell; posterior crossvein removed from the border of wing on fifth vein by as much as the length of second posterior cell; second posterior cell very short; first posterior cell narrowly open.

Length 3 mm.

Three specimens, Hop Canyon, Magdalena Mts., N. M., in August; 7,500-8,500 feet.

**Platypeza egregia n. sp.**—Pl. 12, figs. 4 and 5,

Female. Cinereous, opaque. Head concolorous; antennæ black; proboscis and palpi dilutely lutescent. Humeri brownish; dorsum of thorax with four fuscous stripes, the lateral ones abbreviated anteriorly and less distinct than the approximate intermediate pair; the latter shortened behind. First segment of abdomen cinereous, opaque, beneath the scutellum, opaque black; segments two to six in front with opaque black bands greatly widened in middle, triangular; triangle of third segment largest, of sixth very small. Pile light at base of abdomen changing to black on posterior segments. Legs sublutescent, femora and last tarsal joints infuscate; first two joints of hind tarsi (Pl. 12, fig. 4 outside; fig. 5, inside) on inside with short, thick, yellowish pile; on outside of these joints and on remaining joints, the pubescence is black; third and fourth joints on outside with wide, shallow depression as in *P. calceata*, female (Pl, 12, fig. 3); fourth joint truncate at distal end. Halteres dilutely lutescent. Wings hyaline, with very slight fuscous tinge, veins fuscous; second costal cell twice as broad and nearly twice as long as first basal cell; posterior crossvein far removed from border of wing; posterior branch of fourth vein long; second posterior cell short.

Length 3½ mm.

One specimen, Hop Canyon, Magdalena Mts., N. M., in August; about 8,000 feet.

**Platypeza cinerea n. sp.**

Female. Cinereous. Head concolorous; antennæ black, with slight cinereous pubescence; proboscis and palpi lutescent; pile of head black. Thorax cinereous, more fuscous on dorsum; two median dorsal fuscous stripes and two wider, poorly defined stripes on the side, abbreviated in front; humeri brownish. Abdomen cinereous, banded with opaque black; first segment cinereous except on sides and hind margin where it is black opaque; segments 2-4 with opaque black bands on their posterior borders, widened in middle and reaching anterior margin of their segment; pile of body black. Legs

fusco-cinereous-black; four front tarsi lutescent except last two joints; hind tarsi very similar to that of *P. calceata*, female (Pl. 12, fig. 3). Halteres yellow. Wings hyaline, with very slight fuscous tinge; veins fuscous; second costal and first basal cells subequal; second basal cell one-half the length of first; posterior crossvein near wing-border; second posterior cell moderately long; posterior branch of fourth vein extending nearly to margin of wing.

Length 3 mm.

Two specimens, Hop Canyon, Magdalena Mts., N. M., about 8,000 feet, August.

This species has a superficial resemblance to *P. egregia* but differs principally in the black abdominal triangles being posterior rather than anterior, and in the venation.

## CALLOMYIA.

The American species of this genus hitherto described are *divergens* Loew and *notata* Loew, from Pennsylvania; *talpula* Loew, from New Hampshire; *tenera* Loew, from New York; and *bella* Will., from Mexico. In addition to these Scudder has described* a fossil *Callomyia* from Green River, Wyoming, *C. torporata*.

**Callomyia venusta n. sp.**—Pl. 12, figs. 9 and 10.

Male, female. Head black, ashy sericeous. Antennæ fuscous black, third joint short-conical; proboscis and palpi yellowish red; occiput with black pile, in male covering most of its surface, in female confined to the orbital row. Thorax globose, velvety black; two large lateral gray sericeous spots in front, and a broad prescutellar band of same color; dorsum in middle with two rather narrow, less opaque stripes. Scutellum velvety black with several long black bristles on border. Pleuræ gray sericeous. Abdomen velvety-black except the second and third segments and the posterior half of the first, which are orange-yellow; first, second and fifth segments with a silvery sericeous coating, less marked in the male; pile of abdomen long, black, scattered, thicker in male. Legs in the female yellow; four front tarsi black on the last three or four joints; hind femora with blackish preapical spot; hind tibiæ and tarsi fuscous-black; legs of male darker, the front and middle legs infuscated and the hind femora fuscous black. Halteres saturate reddish-orange. Wings hyaline with very slight yellowish tint.

Length 3½ to 4 mm.

Two males and two females, Hop Canyon, Magdalena Mts., N. M., 8000-9000 feet, latter part of July and August. Found running

*Tertiary Insects of N. A., p. 555.

about on leaves. A very beautiful species and not unlike in general coloration the European *C. amœna* and *leptiformis* except that in those species the males differ exceedingly from the females.

**Callomyia aldrichii n. sp.**

Female. Head black; front and face metallic blackish green, somewhat glaucescent; occiput opaque black and this color extends upon the vertex, enveloping the large elliptical ocelli; antennæ brown, third joint fuscous, ending acutely, two-thirds length of arista. Thorax and scutellum shining, metallic, with bluish-white refiction in some lights and green in others- Abdomen subcupreous, in some lights a little glaucous or whitish-green, shining almost everywhere; bands of abdomen copper-colored, that of first segment being widely interrupted by a large opaque black spot extending the length of segment; on the second segment the cupreous is narrowly interrupted at the basal incisure and leaves upon the middle of segment a large shining blackish triangle; bands of following segments uninterrupted, leaving upon their posterior borders blackish areas, triangular in shape and in the specimen described, subopaque on segments 4-6. Legs pale yellow, hind femora near tip and last two or three joints of tarsi infuscated. Halteres black. Wings hyaline.

Length 3 mm.

A single specimen collected by Prof. J. M. Aldrich on the University of Kansas campus.

This species is near *C. tenera*. Lw.

I desire to thank Dr. Williston for his kind assistance in the preparation of this paper.

# On a Special Class of Connected Surfaces.

BY ARNOLD EMCH.

Students of higher mathematics well know what an important place the Riemann's Surfaces occupy in the Theory of Functions. The interest in this branch of mathematics will doubtless be largely increased in this country since the appearance of the excellent books on this subject by Forsyth, and by Harkness and Morley, which will certainly contribute to exacter logic, formality and intuition in mathematics.

My intention is to illustrate the utility of the theory of functions in geometry. The reader, however, will understand that by this illustration I do not mean a full development of the geometrical features of the general theory of functions, or a treatment of certain problems related to functions. A simple example out of many possible ones may show that the study of the theory of functions, and here especially of Riemann's Surfaces, suggests new points of view and ideas in branches of mathematics which do not seem to be related in any way with the others; and that it is, therefore, of great importance for mathematics in general.

In regard to the general subject of Connected Surfaces and Riemann's Surfaces, I refer to Chapter XIV and XV of the book of Forsyth already mentioned. There we see that surfaces are at present being considered in view of their use as a means of representing the value of a complex variable. Surfaces used for this purpose may be classified according to their connectivity; and the question now arises whether all surfaces of the same connectivity are equivalent to one another, so that they can be transformed into one another.

As long as continuity is maintained, geometrical transformation as as well as physical deformation may affect the surface without destroying the possibility of representing the values of a complex variable on it, provided that certain conditions are satisfied. Hence in the continuous deformation of a surface there may be stretching and bending; but there must be no tearing and there must be no joining. It is not necessary that the deformation of a surface, without tears or joints, be actually possible; and it is sufficient that there exists a point-to-point transformation between the surfaces in which

the variables are represented. Thus a ribbon with an even number of twists would be as effective as a cylinder, and yet could not be physically deformed into a cylinder or a plane. The necessary and sufficient condition for the equivalence of two bifacial surfaces is, therefore, that they must have the same connectivity.

Now we can give an example which is an exception to this case. The unifacial surface can be neither deformed nor transformed into a bifacial surface. On two such surfaces a point-to-point transformation is no longer possible, and thus unifacial surfaces must be excluded from the representation of a complex variable. Unifacial and bifacial surfaces are both of connectivity two, but are altogether different in character as far as the representation of a complex variable upon them is concerned. From this point of view it is interesting to study these surfaces in particular and in a more geometrical way.

In Topology the problem of unilateral and bilateral surfaces, as Moebius calls them, has already been treated several times, and many years ago. I refer the reader who wishes to know more about the investigations in Topology to the following principal authors:

Listing:—Vorstudien zur Topologie, Goettinger Studien, 1847.

Tait:—On Knots. Transactions of the Royal Society of Edinburgh of 1879; and Kirkman in the same volume.

Simony:—Neue Tatsachen aus dem Gebiete der Topologie, Math. Annalen, Vol. XIX and XXIV.

In these treatises may be found almost all the topological properties of unifacial and bifacial surfaces. Only surfaces come into consideration which are liable to topological operations and no reference is made to their employment in other investigations. Starting from the theory of connected surfaces I shall make use of its terminology; and I shall not only consider the result of one loup-cut extended over the whole surface, but also the case of any even or odd number of loup-cuts dividing or transforming the surface into other surfaces of the same connectivity.

In order to represent unifacial and bifacial surfaces in a practical way, we can give a ribbon, previous to being closed, any number of twists. The ribbon represents a unifacial surface if it has an odd number of twists and a bifacial surface of it has an even number of twists. In the first case it is always possible to get from one point of the surface to its opposite point—two such points must be considered as opposite points on the two faces of the ribbon—without crossing the boundary; while it is not possible in the second case. The origin of the words *unifacial* and *bifacial* is to be found in this fact.

Let us now draw a cross-cut in a unifacial surface perpendicular to

the boundary of the surface and divide this cross-cut into $2a-1$ equal parts. At each of these division points let a loup-cut be drawn parallel to the boundary of the surface; we obtain in this manner $a-1$ bifacial surfaces of double the length of the original surface, i. e. of double the length of the middle line of the ribbon, and one unifacial surface of the same length as this middle line. If the above mentioned cross-cut be divided into $2a$ instead $2a-1$ equal parts and the loup-cuts be drawn as before, we shall obtain $2a$ new surfaces all of which are bifacial and all of length equal to the middle line of the ribbon.

Each loup-cut drawn parallel to the boundary of a unifacial surface from the middle point of the cross-cut produces a bifacial surface having double as many twists as the original. A loup-cut drawn in a bifacial surface divides it into two other bifacial surfaces, each with the same number of twists. If a loup-cut starts from the division point $a-1$ of the cross-cut, a unifacial surface is divided into $a-1$ bifacial surfaces, each having double as many twists as the original, and into one unifacial surface with the same number of twists.

Designating by $a$ any positive integral number, the following table of numerical results can be given:

| Number of twists and divisions. | Original Surfaces. Unifacial. | | | | Bifacial. | |
|---|---|---|---|---|---|---|
| Original twists | $2n-1$ | | $2n-1$ | | $2n$ | $2n$ |
| Number of divisions | $2a-1$ | | $2a$ | | $2a-1$ | $2a$ |
| | u. f. | b. f. | u. f. | b. f. | | |
| Number of surfaces after having made the cuts | 1 | $a-1$ | — | $a$ | $2a-1$ | $2a$ |
| Number of twists in each new surface | $2n-1$ | $2(2n-1)$ | — | $2(2n-1)$ | $2n$ | $2n$ |

The number $n$ is of course a positive integer. If $n>0$, any loup-cut divides the corresponding unifacial surface into a bifacial and a unifacial surface which enclose each other. Drawing the loup-cut in the middle, the surface becomes a bifacial surface with a knot. This knot has a certain character depending on the number $n$ and it shall be the object of my next consideration.

The new surface has $2(2n-1)$ twists of the same sense and its knot is independent of these twists, so that the knot can be pushed along the whole surface. Any part of the surface can be interchanged with any other part; and since no part has a particular determined position it must be possible to give to the surface a symmetrical shape in which the twists and the knots are conspicuous.

I shall make such an arrangement so as to have the configuration in a plane. A point-to-point correspondence between a limited part

of a plane or a cylinder and the bifacial surface is always number though a physical deformation of the one into the other canot be done. But the surface can be put entirely in the plane, if a n and of foldings are made. Each folding is then equivalent to a is, Let $m$ be the number of required foldings, so that $m-2(2n$ foldings are left which correspond to zero twists. Now two twist e. opposite sense cancel each other; two folds as given in Fig. 2, to XIII, illustrate this process, while the folds as in Fig. 1 repre a- twists of the same sense. From this it follows that $m-2(2n-1)$ must be an even number, therefore $m$ must be an even number; i. e.

*Only an even number of foldings can transform a bifacial surf at into a plane figure.* See Figs. 4 and 7. on

Also $m-(2n-1)=k$ must be an even number; but this is tly only when $m$ is odd. Therefore:--

*An original unifacial surface can be transformed into a plan figure only by an odd number of folds.*

We have also the converse theorem:

*If such a plane figure has an odd number of foldings, it represents a unifacial surface.* Figs. 3, 5 and 6 illustrate these cases.

It will be noticed that certain parts of the plane figures cover each other either twice or several times.

There are a great number of representations possible according to the value of $k$. The case $k=o$, or $m=2(2n-1)$, is the most interesting, because it gives the best conception of the twists and the knots. Figs. 8 and 9 on Plate XIII show the cases $n=1$ and $n=3$. For $2n=1$ there is no knot, but a bifacial surface of two twists cannot be represented by a plane figure of only two folds. A bifacial plane figure has therefore at least four folds. In this case $k=2$, and it is illustrated in Fig. 7. Fig. 3 represents a plane unifacial surface with three twists.

In Figs. 8 and 9 the character of the knot is apparent at the center. Each part of the surface crossing the center covers the foregoing part. All the parts together make up a geometrical group* as is evident from the standpoint of Klein's definition of a group in the most general sense.

From the generation of unifacial and bifacial surfaces as treated in this paper, it is obvious: *A unifacial surface can never have a knot.*

How loup-cuts affect a bifacial surface, I have mentioned already. Fig. 10 illustrates such a case of three loup-cuts being made in a unifacial surface with three twists. Another case is added, Fig. 11, where four loup-cuts were make in a bifacial surface with four twists.

*See Klein's Einleitung in die hoehere Geometrie. Vol. II.

The study of complex figures resulting from any number of loup-cuts drawn in either a unifacial or a bifacial surface would be the next step; but all the problems of this sort can be solved by combinations of the simple cases, and so may be left as exercises for the reader.

Finally it is well to mention the fact that the well known theorem of Gauss could not be employed in accordance with the treatment herein given. Suppose the boundaries of the bifacial surfaces to be closed curves, and x, y, z, the co-ordinates of any point in the one curve and x', y', z', the co-ordinates of any point in the other, and $\triangle$ the determinant

$$\begin{vmatrix} x-x' & y-y' & z-z' \\ dx & dy & dz \\ dx' & dy' & dz' \end{vmatrix}.$$

The double integral extended over both lines,

$$\iint \frac{\triangle}{\{(x-x')^2+(y-y')^2+(z-z')^2\}^{\frac{3}{2}}} = 4m\pi.$$

where $m$ is the number of twists, expresses the theorem of Gauss.*

In order to aid in the practical calculation of the integral, one of the curves can be brought by bending into a horizontal plane. A point that describes the second boundary in the same direction may pass a twist either by crossing the plane from above to below, or from below to above. Thus there are two kinds of twists to be distinguished in the solution of the integral; and its numerical value is $4\Sigma(a-b)\pi$, in which $a$ is the number of twists of the first kind and $b$ is the number of the second kind. $\Sigma$ is $+1$ or $-1$ according as $a-b$ is positive or negative. In the example discussed above a distinction between the two kinds of twist was not necessary, and therefore the numerical value of Gauss' integral is illusory and of no avail in those cases.

*O. Simony. Math. Annalen. Vol. XXIV, p. 278.

# Foreign Settlements in Kansas.

BY W. H. CARRUTH.

(With Map.)

The present number of the UNIVERSITY QUARTERLY furnishes the complete map of foreign settlements in Kansas promised in Vol. I, No. 2. Referring to the article there, I add the details of other counties with revised summaries. I am enabled to print the map through the co-operation of Mr. F. D. Coburn, Secretary of the State Board of Agriculture.

Atchison.—No detailed report, but has according to the census of the Fifth Biennial Report of the State Board of Agriculture, Germans 1500, Irish 690, Skandinavians 190, and a total foreign-born population of 3620, mostly in the city of Atchison.

Barber.—No detailed report, only small numbers of foreigners scattered through county; Germans 42, Skandinavians 15.

Barton.—Germans about Ellinwood; about Odin and to n. line of county Austro-Hungarians and Luxemburgers; also about Olmutz Austrians; Russo-German Lutherans in the northwest corner of the county. In all these settlements (over 1600 Germans), churches and in several, schools.

Bourbon.—No distinct settlements, but 450 Germans and a few other foreigners in the county, mostly in Ft. Scott and in the coal mines.

Brown.—One settlement of Bohemians (German-speaking) about Everest. No church or school in German. Many Germans scattered through the county, about 650 altogether.

Clarke.—No settlements reported.

Clay.—Swedes about Morganville and Lund; French in the northwest corner of the county; English in the southeast corner. All these settlements made about 1873. Germans in the county about 750; Skandinavians 850; French 20.

Finney.—Two German settlements, one northwest, the other southeast of Ravenna, about 60 souls. They bear the names of Harmonia Settlement and Johann Settlement, and both came in 1885, being from East Friesland, Prussia and Lippe. They have church and Sunday-school in German.

Franklin.—No settlement. About 300 Germans and 250 Skandinavians scattered over the county, and in the city of Ottawa.

Grant, Gray, Hamilton, Haskell.—No reports of foreign settlements.

Johnson.—About 300 Germans scattered through the county.

Kearney.—A few families of Germans, and a colony of Swedes east of Chantilly, much larger when it settled here in 1886. Both Swedes and Germans still use their native tongue.

Kiowa.—Small settlement of Germans southeast of Greensburg, located in 1885. Had church service in German at first, but have dropped it.

Lane, Linn.—No settlements, though there are about 150 Germans in the latter county.

Meade.—Twenty families of Germans in Odee township, settled in 1885. They have both church and school in their own tongue.

Morton.—Reports no foreign settlements.

Ness.—A small settlement of Germans about Ransom.

Pratt.—Reports no settlements; about 100 Germans in the county.

Republic.—Bohemians in northeast portion of county; Swedes and Norwegians in southwest, both in large numbers, and settled 1870-71. They maintain church and schools in the native tongue.

Russell.—Russo-German Mennonites in southwest portion of the county.

Seward.—Reports no foreign settlements, but a few Germans in the county.

Scott.—About 20 families of Russians located in 1892 on west border of county. They are Catholics (Greek Church) and have services in native language.*

Sheridan.—About 100 Germans scattered over the county.

Stevens.—No foreigners.

Sumner.—One settlement of Bohemians about Doster in the southwest corner of the county, about 300 persons; still speak their language but do not have church service conducted in it. About 300 Germans scattered over the county.

Trego.—A small settlement of Germans about Colono; one of Bohemians about Bosnia; in both the native tongue is spoken, but no church service conducted in it.

Wichita.—A Russian settlement of about 25 families is located on the Mo. Pacific R. R. on the east side of the county. They have both church and school in their own tongue.†

†This settlement is omitted from the map.

*This settlement was omitted from the map.

Woodson.—Considerable settlements of Germans in the southeast corner of the county, and west of Yates Center. In both church service is conducted in German.

These additional reports together with corrections in the former paper for the counties of Coffey, Dickinson, Ellis, Garfield, Hodgeman, Labette, Leavenworth, Lyon, Osborn, Riley, make necessary a revision of the summaries there given, with the following result:

SUMMARIES:

There are German settlements of thirty or more persons in the following counties: Allen, Anderson, Atchison, Barton, Brown, Butler, Chase, Chautauqua, Cherokee, Cheyenne, Coffey, Comanche, Cowley, Crawford, Decatur, Dickinson, Doniphan, Douglas, Edwards, Elk, Ellis, Ellsworth, Finney, Ford, Garfield, Geary, Greenwood, Harper, Harvey, Hodgeman, Jefferson, Kingman, Kiowa, Leavenworth, Lincoln, Marion, Marshall, Meade, Miami, Mitchell, Montgomery, McPherson, Nemaha, Neosho, Ness, Norton, Osage, Osborne, Phillips, Pottawatomie, Rawlins, Reno, Rice, Riley, Rooks, Rush, Russell, Saline, Sedgwick, Shawnee, Sherman, Smith, Stafford, Stanton, Thomas, Trego, Wabaunsee, Washington, Woodson, Wyandotte.
Total, 70.

Skandinavians in settlements of thirty or over are found in: Allen, Chautauqua, Cherokee, Cheyenne, Clay, Cloud, Cowley, Crawford, Decatur, Dickinson, Doniphan, Edwards, Elk, Gove, Greeley, Greenwood, Hodgeman, Jackson, Jewell, Kearney, Labette, Lincoln, Logan, Lyon, Marshall, Morris, McPherson, Neosho, Osage, Ottawa, Pawnee, Phillips, Pottawatomie, Rawlins, Republic, Riley, Saline, Sedgwick, Sherman, Wabaunsee, Wallace, Wilson, Wyandotte.
Total, 43.

Settlements of Slavonic peoples, Bohemians, Poles, Russians, or Hungarians, in: Decatur, Ellsworth, Harper, Lincoln, Marshall, Ottawa, Phillips, Rawlins, Reno, Republic, Riley, Rooks, Rush, Scott, Sedgwick, Sumner, Trego, Washington, Wichita. Total, 19.

Settlements of Irish have been made in: Anderson, Cloud, Crawford, Dickinson, Doniphan, Elk, Geary, Jackson, Kingman, Marshall, Miami, Nemaha, Osage, Ottawa, Pottawatomie, Washington, Wyandotte. Total, 17.

French are found in settlements of thirty or more in: Cherokee, Clay, Cloud, Crawford, Doniphan, Graham, Harper, Harvey, Nemaha, Osage, Pottawatomie, Rooks, Sedgwick, Washington. Total, 14.

Italians are in Cherokee, Crawford, Sedgwick. Total, 3.

Welsh in Coffey, Lyons, Osage, Riley and Wyandotte. Total, 5.

Dutch in Phillips, Reno, Sedgwick. Total, 3.
Scotch are reported from Cherokee, Labette, Osage. Total, 3.
English in Clay, Ellis, Geary and Doniphan. Total, 4.

The following counties report that there are no settlements of people of foreign birth within their borders; Clarke, Grant, Gray, Hamilton, Haskell, Lane, Morton. Total, 7.

Ninety of our Kansas counties report settlements of citizens of foreign birth in numbers above 30. In so many cases there is no report or estimate of numbers that it is not worth while to give summaries. Probably there are not actually ten counties that have not such settlements. Attempts to secure returns for English, Scotch and Irish have been generally unsuccessful owing to the inability of my informants to discriminate these as foreigners.

Church services in a foreign tongue are held as follows: Allen S.,* Anderson G., Barton G., Butler G., Chase G., Cheyenne G., Cherokee G., Cloud F. S., Coffey G., Decatur G., Dickinson G. S., Doniphan G., Douglas G., Edwards G. S., Ellis G. Rus., Ellsworth G., Finney G., Ford G., Geary G., Graham F., Greeley S., Greenwood G. S., Harper G. Hung., Harvey G., Hodgeman G., Jefferson G., Leavenworth G., Lincoln G. Du., Logan S., Lyon W. G., Marion G. Boh., Marshall G., Meade G., Miami G., Mitchell G., Montgomery G., Morris S., McPherson S. G., Nemaha G., Neosho G. S., Norton G., Osage S. W., Osborne G., Pawnee S., Phillips G. Du., Pottawatomie G. S., Rawlins G., Reno G. Du. Rus., Republic S. Boh., Rice G., Riley S. W., Rooks F. G., Rush G., Saline G. S., Scott Rus., Sedgwick G., Sherman G. S., Smith G. Du., Stafford G., Wabaunsee G., Wallace S., Washington G., Wichita Rus., Wilson S., Woodson S., Wyandotte G. S. Total, 65.

This total of sixty-five counties in which church service is held in a foreign tongue does not at all indicate the number of such churches. In many of the reports received the number is not given, or merely in the plural. These very incomplete reports indicate one hundred forty-eight such churches; it is safe to say that the number is nearly double this.

More interesting is the number of schools conducted in a foreign tongue. The counties having them are: Allen S., Anderson G., Barton G., Chase G., Cheyenne G., Cherokee G., Cloud F., Dickinson G. S., Douglas G., Ellis G., Ellsworth G., Ford G., Geary G., Greeley S., Harvey G., Leavenworth G., Lincoln G. S., Logan S., Marion G., Marshall G., Meade G., Mitchell G., Morris S., McPherson S.

*G—German, S—Skandinavian. F—French, W—Welsh. Du—Dutch.

G., Nemaha G., Osborne G., Phillips G., Pottawatomie G. S., Rawlins G., Reno G. Du. Rus., Republic S. Boh., Riley S., Rush G., Saline S., Sedgwick G., Sherman G. S., Smith G. Du., Wabaunsee G., Wallace G., Washington G., Wichita Rus. Total, 41.

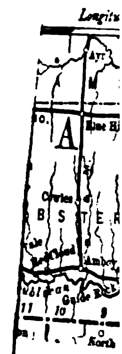
The number of separate schools in a foreign language so far as reported is eighty, and here, too, it is safe to say that the actual number is much larger.

## EXPLANATION.

The spaces indicating settlements are in many cases too small to admit a complete description of the inhabitants, and accordingly they have been marked by races rather than by nationalities and tribes. Wherever reports indicate that the foreign settlers are interspersed with native Americans the territory is gridironed. About large cities the grouping of colors makes no attempt to indicate the quarter in which the various nationalities are situated. "German" is made to do duty for all inhabitants of Germany whether Low or High, as well as for Austria, German Swiss, and Russo-German Mennonites. The last are reported simply as Mennonites, but are, I believe, in all cases of German origin. "Skandinavian" is used instead of Swede, Norwegian and Dane, because in some cases the distinction was not made in the reports, and in order to limit the number of colors on the map. In the case of Scotch I have been unable to secure information whether they are Highlanders or Lowlanders, and in case of Irish, to what extent, if at all, they speak the old Irish language.

SE

'H, Prof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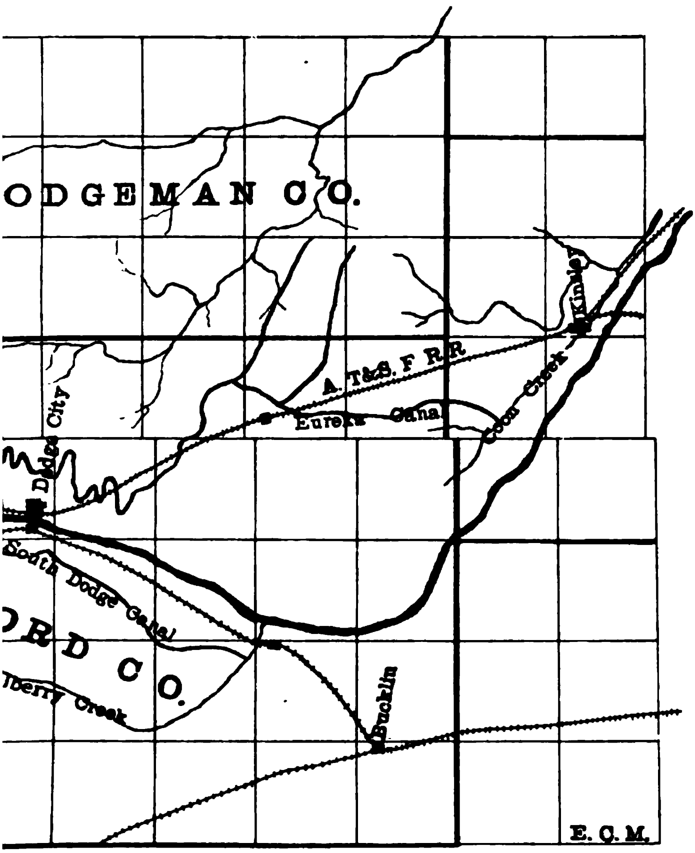
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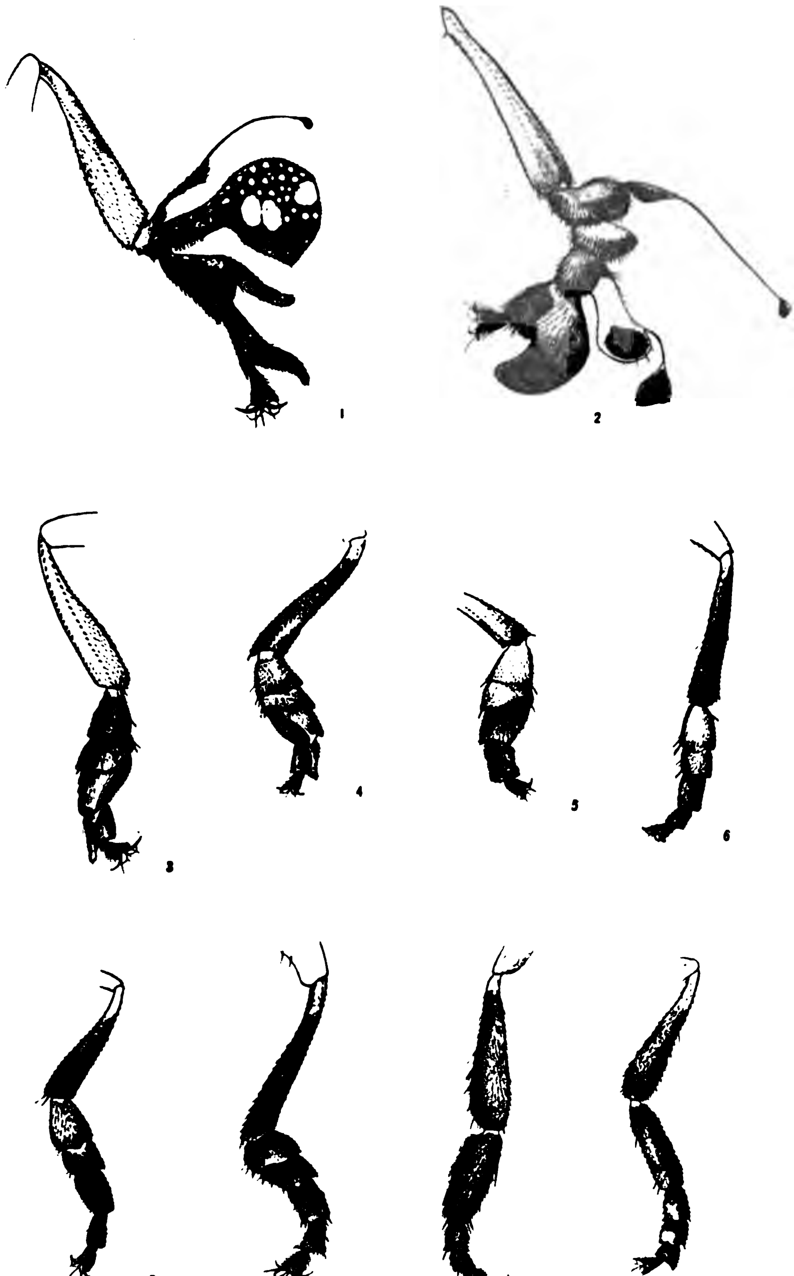
A. T&S. F R.R.
Eureka Canal
Coon Creek
McKinley
Dodge City
South Dodge Canal
RD CO.
Creek
Bucklin
E. C. M.

.S.

## PLATE XII.

Fig. 1. *Platypeza calceata* Snow. Hind leg of male.
Fig. 2. *Platypeza ornatipes* Towns. Hind leg of male.
Fig. 3. *Platypeza calceata* Snow. Hind leg of female.
Fig. 4. *Platypeza egregia* Snow. Hind leg of female, outside.
Fig. 5. *Platypeza egregia* Snow. Hind leg of female, inside.
Fig. 6. *Platypeza pulchra* Snow. Hind leg of male.
Fig. 7. *Platypeza umbrosa* Snow. Hind leg of male.
Fig. 8. *Platypeza velutina* Loew. Hind leg of male.
Fig. 9. *Callomyia venusta* Snow. Hind leg of male.
Fig. 10. *Callomyia venusta* Snow. Hind leg of female.

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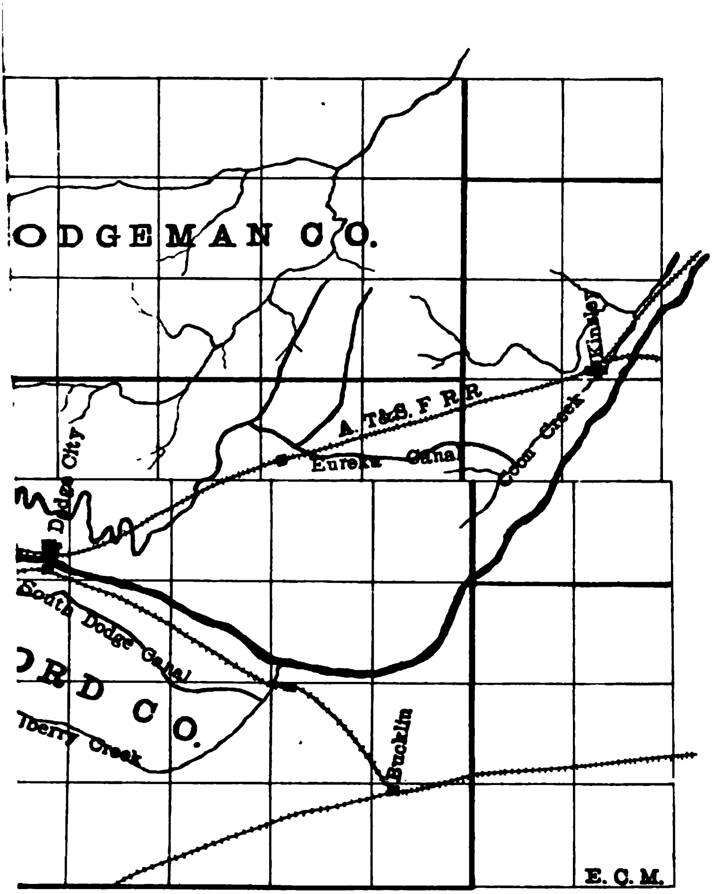
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A. T.&S. F. R.R.
Eureka Canal
Coon Creek
Kinsley
Dodge City
South Dodge Canal
RD CO.
berry Creek
Bucklin
E. C. M.

.S.

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KANSAS UNIVERSITY QUARTERLY.

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# New or Little Known Extinct Vertebrates.

BY S. W. WILLISTON.

(With Plates XIV to XIX.)

Fifty-two years ago, Dr. Augustus Goldfuss presented to the Geologische Section der Naturforscher-versammlung zu Mainz the description of certain remains of a Mosasaur discovered some time previously by Major O'Fallen in the vicinity of Big Bend of the upper Missouri river and secured by Prince Maximilian of Wied, by whom they were presented to the museum at Bonn. His paper was published two or three years later in the Acta Acad. Caes. Leop. Carol. Nat. Cur., vol. xxi, with four excellent plates. As Baur has said, had later authorities studied this paper more attentively they would not have claimed as new a number of discoveries made and published long before, among which may be mentioned the position of the quadrate bone, the presence of the quadrato-parietal and malar arches, and the sclerotic plates.

In 1882, Dollo established on this species a new genus, basing it upon the supposed union of the pterygoids in the median line. This character was suspected to be a deformity by Cope, and has recently been so established by Merriam.* The other distinctive characters which Dollo gave are unimportant. They are as follows: "Crane comprimé de haut en bas. Borde dentaire du pterygoide droit et portant dix dents. Prémaxillaire impair avec face supérieure aplatie." For Mosasaurus: "Crane plutot comprimé lateralement. Borde dentaire du pterygoide recourbé et portant huit dents. Prémaxillaire impair avec face supérieure en carène."†

Of these characters, the first does not exist—the pterygoids are not united in the middle line nor are even contiguous. There is no more depression of the skull than occurs in other forms of the order. The specimen described and figured in the present paper,

*In lit. Dr. Merriam has kindly communicated a number of other interesting facts concerning this specimen, which, with his permission, will be published in a future paper.

†Bull. du Mus. Royal d' Hist. Nat Belg. 1, p. 7, 1882.

which can not possibly be separated from *M. maximiliani* generically, has but eight teeth on the pterygoid, as in *M. camperi.* The character of the premaxillary is valid, but not generic.

The genus *Pterycollasaurus,* as defined by Dollo, thus rests upon errors, and has been rejected. Nevertheless, I am not sure but that Goldfuss' species and the one described in the present paper are entitled to generic separation from *Mosasaurus.* This however, in the absence of more complete knowledge of the typical *Mosasaurus,* I cannot decide at present. Dollo has recently shown that *Liodon* Owen is a synonym of *Mosasaurus.* If so, it seems apparent that the present species is not of the same genus, for certainly the figure of the skull of *L. anceps* given by Owen shows a distinct difference from that figured herewith.

During the past summer, the University of Kansas Geological Expedition to the Bad Lands of Dakota was fortunate in obtaining, among other valuable material, what I believe to be the most perfect skull of a Mosasaur yet known in any museum. The specimen, which includes nearly the entire skull, the larger part of a front paddle and about forty vertebrae, has been mounted in the University Museum and figures of this skull as mounted, are given in the accompanying plates. The only bone of the skull that is missing is the jugal of the right side; that of the left side was dislocated and enclosed in the hard matrix of the orbit, from which it has not been extricated. Like most specimens from the Pierre Cretaceous it was enclosed originally in a hard, nodular matrix of a bluish color, from which the larger part of the skull had gradually been oxidized, leaving the bones in the utmost perfection. A part of the bones, however, "waren von einem sehr harten, feinkörnigen, dichten Kalksteine mehrere Zoll dick umgeben, welcher im Inneren grösserer Stücke bläulichgrau, weiter nach aussen ochergelb und weicher ist" (Goldfuss), and which has been removed with difficulty.

As cleaned and mounted, the specimen gives a most remarkably vivid impression of the skull of the living animal. An extended discussion of its structure and relations is reserved for a later paper.

The specimen, though closely related to *M. maximiliani,* clearly indicates a distinct species, somewhat smaller than *M. camperi,* and fully a third larger than *M. maximiliani.* It offers more tangible differences from the latter species, in the number of the pterygoid teeth and in the much greater width of the posterior part of the mandible. Some of the more important measurements of this skull, whose species I will call *M. horridus,* are given below, in comparison with corresponding measurements taken from the plates of *M. maximiliani* by Goldfuss.

| | *horridus.* mm. | *maximiliani.* mm. |
|---|---|---|
| Length from tip of rostrum to occipital condyle | 880.. | |
| Total length of lower jaw | 1010.. | |
| Width of cranium through postorbital processes | 360.. | 240 |
| Length from anterior end of the nares to the occipital condyle | 690.. | 540 |
| Length of nares | 230.. | 170 |
| Greatest width of frontal bone | 240.. | 168 |
| Length of dentigerous border of mandible | 500.. | |
| Length from end of articular to anterior end of the coronoid | 340.. | 205 |
| Width of mandible through middle of coronoid | 130.. | 85 |

There are fifteen teeth in the mandibles, and sixteen in the upper jaw, two of which, on each side, are in the premaxillary. They show facets, as figured for *M. maximiliani.* A marked peculiarity of the present specimen is the structure of the outer end of the ectopterygoid process. It has a vertical face, directed outward and abutting against the coronoid; it shows no trace for union with a transverse bone. The face is slightly concave vertically, and flattened antero-posteriorly, measuring in the former direction, 65 millimeters, in the latter 25.

The hypopophyses of the cervical vertebrae are free, and the chevrons of the caudals are firmly united. There are rudimentary zygosphenes on the anterior vertebrae. In the hopes of rendering the coracoid and scapula more complete, I have not figured them. The coracoid is apparently not emarginate, and both bones resemble those of *Clidastes.* The parts found in apposition are figured in plate XVI. The front paddle of the typical species of *Mosasaurus*, notwithstanding that the genus has been known for so long, is yet unknown. Dollo says: "Les os du carpe que nous possédions et une nageoire antérieure quasi-entière nouvellement entrée montrent de telles analogies entre *Mosasaurus* et *Clidastes* qu'il paraît certain que les membres de devant du premier étaient, aussi, functionellement pentadactyles."* There is no longer doubt of the pentadactyle character of the front feet of *Mosasaurus*, if the present species belongs to that genus. Dollo has shown (l. c.) on the other hand that *Mosasaurus* has but four digits in the hind paddle, and in all probability our species will prove to have the same number. One will await with interest the publication of the distinguished Belgian anatomist's researches upon the front paddle of *Mosasaurus.* By examination of the plate herewith given the striking similarity of the front paddle of *Clidastes* and *Mosasaurus* will be evident. This similarity is of the more interest because of the fact that both genera show the highest degree

*Bull Soc. Belg. de Geol. iv, 249. 1894.

of specialization in the Pythonomorpha as well as its latest development. The genus *Clidastes* occurs in the Ft. Pierre Cretaceous, as I have already shown, and as a recently received specimen from Colorado indicates. A comparison of the figure of the paddle here given with those of *C. velox* and *C. Westii* previously given by the writer* will show certain differences of interest. In *C. velox*, from the Niobrara, the second carpal bone of the first row is separated by a distinct interval from the radius, the scaphoid showing a distinct interosseous border. At its other extremity it scarcely touches the ulna and has no articular facet for that bone. In *C. Westii*, from the lowermost Ft. Pierre, the free border of the scaphoid is lost and the second bone articulates with the radius, and shows a beginning of an articulation with the ulna. In *M. horridus*, from the Upper Pierre, the articulation with the radius is yet greater and that with the ulna is pronounced. In this last species the humerus is remarkably stout and the tuberosity of the proximal end rises higher above the head than in *Clidastes*. Altogether these differences show a progressively more powerful paddle. This *Clidastes* type of the paddle was already apparent from the figures given by Leidy (Cretaceous Reptiles of the United States, Pl. iv).

The affinities between these two genera, it is thus seen, are much greater than those of either with any other. They offer certain structural peculiarities in common that separate them readily from other Mosasaurids, and it has long seemed to me, that were these peculiarities those of existing lizards there would be no hesitancy in assigning to them a family value. At present, but one family, Mosasauridæ, is recognized in the order, Plioplatecarpidæ, founded chiefly upon a supposed sacrum, having been given up by its author. The genera now recognized as belonging to the Pythonomorpha are as follows:

Mosasaurus Conybeare, 1824. Europe, North America.
Clidastes Cope, 1869. North America.
Baptosaurus Marsh, 1869. North America.
Platecarpus Cope, 1869. North America, New Zealand (?).
Tylosaurus Marsh, 1872. North America.
Sironectes Cope, 1875. Kansas.
Plioplatecarpus Dollo, 1882, Europe.
Hainosaurus Dollo, 1885. Europe.
Prognathosaurus Dollo, 1889. Europe.

These eight or nine genera seem well established, although I have some doubts of the validity of *Sironectes*, and it is not improbable that the genus *Holosaurus* Marsh may yet be found valid, though not

*Kans. Univ. Quarterly. I. 1892, p. 1, plates i-iv.

so proven by characters hitherto given. I believe that we yet have not a little to learn of these animals from the later American Cretaceous. In the University Museum there is a large part of an individual from nearly the same horizon as that of *M. horridus*, which I am not yet able to refer to any known genus, and which I believe will prove to be distinct. It is remarkable for the very broad head, short jaws, with only eleven teeth in the maxilla and thirteen in the mandible, stout, unfaceted teeth and peculiarities of the limb bones which distinguish it from *Platecarpus*, its nearest ally. The length of the jaws is 1050 mm, and the width of the frontal bone 285 mm. while the transverse diameter of the centrum of the third cervical vertebra is 48 mm., showing a remarkably large head for the size of the body. The quadrate is peculiar in having the supracolumellar process co-ossified with the body at its extremity. The species, which I shall call *Overtoni*, for my assistant Mr. T. R. Overton, who discovered it near the top of the Ft. Pierre of the Cheyenne River, will be described and figured at an early date.

Of these genera I would separate *Mosasaurus* (and *Pterycollasaurus* if distinct) and *Clidastes* as a distinct family upon the following skeletal characters. The characters of the skull I will discuss at length in a future paper.

**Mosasauridæ** Conybeare, 1824 (*Clidastidæ* Cope, *Edestosauridæ* Marsh).

Humerus with a prominent radial process at the distal end; carpus and tarsus composed of fully ossified bones closely articulating with each other and with the adjacent bones; hind feet tetradactyl; tail vertically flattened, the trunk relatively long; chevrons co-ossified; sternum calcified.

**Tylosauridæ** Marsh (nomen nudum), Amer. Journ. Sci. xii, July, 1876.

Humerus expanded distally, but without radial or ulnar processes; carpus and tarsus largely cartilaginous, with three or four nodular ossifications not closely articulating with each other or with the adjacent bones; hind feet pentadactyl (?); chevron bones free; tail not vertically flattened and relatively long; sternum and costal cartilages not calcified.

Dollo suggests that Marsh was in error in ascribing five toes to the hind foot of *Platecarpus*, but I believe that Marsh was right. The fifth metatarsal in this genus, as also in *Tylosaurus*, is more elongated than in *Clidastes*, and has a distal articular expansion. I shall figure shortly the hind foot of a specimen in the museum belonging to *Tylosaurus* which I think will prove the existence of pentadactylism.

The discovery of these additional characters of *Mosasaurus* leaves the generic differences between it and *Clidastes* not as conspicuous

as they were. Nevertheless, there can be no question of their distinction, as shown in the more developed zygosphene, the shape of the prefrontals, the number of pterygoid teeth, etc.

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**Dinotomius atrox**, gen. et sp. nov. Machærodontinæ. Plate XVIII.

Among the most valuable acquisitions of the Bad Land Expedition were two skeletons of a large sabre-toothed cat which proves to be new to science. Both skeletons were found on precisely the same horizon and about twenty feet distant from each other, just below the nodular layer which marks the upper limits of the Oreodon beds of Wortman. One of the skeletons, slightly smaller than the other, comprises the nearly complete skull and numerous bones of the skeleton. The skull of the other specimen has been weathered out of the matrix and includes only the posterior part of the cranium and the mandibles with a part of the upper jaw and a canine. Altogether the two specimens include about thirty vertebræ from various parts of the column, a part of one scapula, humeri, ulnæ, incomplete radius, four metacarpals, the pelvis, femora, tibiæ, the ends of the fibula, calcanei, astraguli, cuboids, and one or two carpals. The material, it is thus seen, is sufficient for the nearly complete description of the osteology and restoration of the animal, which will be given in the July number of this Quarterly by Mr. E. S. Riggs and myself.

Char. gener. Dentition: I$\frac{3}{3}$, C$\frac{1}{1}$, Pm$\frac{2}{2}$, M$\frac{1}{1}$. Superior canines much elongated and recurved, with anterior and posterior denticulated cutting edge. Mandible with a ridge separating the front from the lateral faces, and with a deep flange in front. Alisphenoid canal present. Superior sectorial without deuterocone, and with a small anterior median lobe; inferior sectorial with entoconid and rudimentary hypoconid. Entepicondylar foramen present. Femur without third trochanter.

In the shape of the skull, as well as in other characters, the genus seems to approach *Machaerodus* most closely, and it is possible may not be distinguished from it in its wide sense.

The sagittal and frontal planes make only a slight angle with each other, less than is the case in any other of the older American Machaerodonts which have been figured. In profile, as well as in the appearance of the lower surface, the skull is more like that of *Smilodon neogæus* Lund. from the Pampas of South America, though a difference is seen in the more slender zygoma as well as in the concave sagittal crest. The brain case is small, having not twice the actual capacity of that of the living Canada lynx, while the animal was four-fifths the size of the African lion. The cranium is much

restricted back of the orbits, where the transverse diameter measures only 40 millimeters, a little more than one-fourth of the entire width of the skull. The occiput is narrow and high.

The mandibular ramus is only moderately stout and its inferior flange is more produced than in any of its known contemporaries. The masseteric fossa is deep, but the coronoid process is small and vertical, much as in *Hoplophoneus*, and quite different from what is figured in *Pogonodon*. The condyle is broad, but the outer part is slender; the angle does not reach further back than the condyle and terminates in a rounded extremity. Altogether, the small coronoid process and the rather slender zygoma indicate less powerful temporal and masseter muscles than one would anticipate for so powerful a dentitional armature.

The infraorbital foramen is large and rounded and a little higher than broad. Its posterior border is situated nearly over the anterior basal lobe of the upper sectorial with the skull resting on the basicranial plane. The condyloid foramen is large, and does not open into the posterior lacerated foramen. The otic bones have been separated from the cranium, but the grooves for the lacerated and carotid foramina are shallow and separated by a low ridge. I can find no post-glenoid foramen in either of the skulls.

The superior incisors are smoothly conical and recurved, placed in an even curve without cingula. The outer ones but little larger and no longer than the inner ones. The superior canines are long, recurved, and denticulated on both margins below. The base of the crown is a flattened oval; the posterior edge becomes thinner below, but does not receive a cutting edge and denticulations for more than an inch below the base of the enamel. Diastema back of the canines equal to about twice the length of the third premolar. Third premolar with a minute anterior basal cusp, the main cusp not very prominent, the posterior lobe forming a straight, sharp, horizontal cutting edge. Sectorial tooth large, with two prominent cusps, which have been ground flat on the inner side in the three specimens; no anterior external or internal basal cusps, the internal, however, represented by a root which is slightly convex; the anterior median basal cusp small and tubercular. Molar larger than in the cats, partially concealed by the posterior edge of the sectorial, placed nearly at right angles to the longitudinal axis of the skull, implanted by two roots (the crown is broken away on both sides).

The lower incisors are broken off, but the basal portions show them to be larger than the upper incisors, the outer one nearly as large as the canine. The canine is conical, curved and pointed. Third premolar rather small, with a less prominent cusp than in *Felis*; no

anterior basal cusp, though the thin edge is slightly convex; heel small, simple. Fourth premolar large, prominent, with the anterior basal cusp better developed than in the cat, the heel simple, with a cutting edge, and its width nearly equal to half the width of the main cusp. Molar much as in the cat, save that there is a well-developed internal posterior tubercle, and the heel is rudimentary.

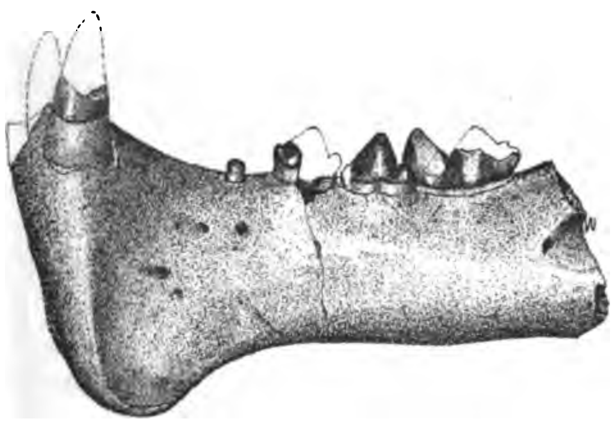
In the following table I give measurements of *Pogonodon platycopis* Cope for comparison:

| | *P. platycopis.* | *D. atrox.* | *Pogonodon?* sp. |
|---|---|---|---|
| Length of inion to premaxillary | 280.... | 260.... | |
| Length from premaxillary border to superior canine | 19.... | 20.... | |
| Length from premaxillary border to line of orbit | 90.... | 97.... | |
| Length from inion to occipital condyle | 48.... | 60.... | |
| Length of inion to furcation of temporal ridges | 115.... | 98.... | |
| Width of zygomata | 192*... | 145.... | |
| Width of occiput at middle | 37.... | 45.... | |
| Width of occiput at condyles | 56.... | 56.... | |
| Width of foramen magnum | 26.... | 22.... | |
| Width of post-tympanic process | 74.... | 80.... | |
| Greatest diameter of orbit | .... | 42.... | |
| Transverse diameter of nares | .... | 26.... | |
| Greatest diameter of infraorbital foramen | .... | 15.... | |
| Length of superior dental series including canine | 90.... | 92.... | |
| Long diameter of base of canine | 26.... | 30.... | |
| Height of chin at flange | 48.... | 80.... | 62 |
| Height of ramus at third premolar | 35.... | 32.... | 32 |
| Height of ramus at first molar | 30.... | 31.... | 31 |
| Length of mandibular ramus | 177.... | 164.... | |
| Height of ramus at coronoid process | 75.... | 50.... | |
| Width of inferior canine at base of crown | | 13.... | 13 |
| Width of second lower premolar | | .... | 3 |
| Length of third premolar | | 12.... | |
| Length of fourth premolar | | 17.... | 16 |
| Length of inferior molar | | 22.... | 23 |
| Length of space between canine and third premolar | | 42.... | 32 |
| Diastema back of second premolar | | .... | 6 |
| Length from anterior margin of the masseteric fossa to the canine ridge | | 100.... | 92 |
| Length of crown of upper median incisor | | 11.... | |
| Transverse diameter of same at base | | 6.... | |
| Length of crown of outer incisor | | 14.... | |
| Antero-posterior diameter of same at base | | 10.... | |
| Length of crown third upper premolar | | 12.... | |
| Length of crown fourth upper premolar | | 25.... | |
| Width of same in front | | 10.... | |
| Length of molar | | 12.... | |
| Width of same | | 6.... | |

*"Approximately."

**(?) Pogonodon sp.**

A single mandibular ramus, wanting the posterior part, and of almost the same size as that of *D. atrox* was found by Mr. B. M. Dickinson, of the University Expedition, near the upper part of the Protoceras beds. It clearly indicates another species, and probably another genus, which I cannot distinguish from Pogonodon. It differs from the corresponding part of *D. atrox* in having a larger canine, less deep flange, and an additional premolar. The jaw, too, is less slender, the distance between the canine and third premolar is less, and it evidently had a stouter coronoid process, as is shown from the basal portion, which begins to ascend immediately behind the molar, instead of at some distance beyond it. Measurements of the jaw will be found with those of *D. atrox*.



Left mandible of Pogonodon ? sp., two-thirds natural size.

**Dinictis (?) sp.**

A fragment of an upper jaw with three teeth, the crowns of which are shown in the cut, found by Mr. T. R. Overton in the Protoceras beds, seems to indicate a species of *Dinictis*, but differs in the hitherto unrecorded peculiarity of having two true molars, the second situated back of the middle of the first. The sectorial measures 22 millimeters in length by 13 in width; the antero-posterior diameter of the first molar is 7 millimeters, its transverse diameter 15; the second molar has its greatest diameter a little over 3 millimeters and its opposite diameter a little less.

Dinictis (?) sp. Left upper sectorial and molars. Natural size.

**Machærodus crassidens** Cragin. (Plate XIX.)

In Science for January 8, 1892, Professor Cragin described from the Loup Fork of Kansas the canine of a sabre-tooth cat under the name of *Machærodus crassidens*. In the University collection there are a number of large felid bones from the same deposit in Phillips County whence Cragin obtained his specimen, and among them there is a large canine which seems indentical with his. I copy below the measurements given by Cragin (reduced to millimeters), and in the second column give the corresponding measurements for our specimen:

| | | |
|---|---|---|
| Breadth of crown at base | 28 | 30 |
| Thickness of same | 20 | 18 |
| Breadth of crown 37 mm. above base, about | 20 | |
| Thickness of crown at same place | 11 | |
| Length of root of crown to origin of denticulated keel | 61 | 60 |
| Length of canine as restored, approximately | 132 | |

The anterior part of the tooth in the present as in Cragin's specimen is worn or broken away, so that it cannot be said whether there was an anterior denticulation or not. On the posterior border there are twelve denticulations in five millimeters.

With this tooth there were found a number of other felid bones belonging to at least two different species. One of them is of almost the size of the lion (*Felis leo*), though more slender, and it seems very probable that the humerus, radius and metatarsals figured in plate XIX belong to the same species, it is not at all unlikely, with the tooth described above. They may, hence, be provisionally known by the name of *Machærodus crassidens* Cragin, though of course it is not certain at all that the genus may not prove to be something else. In the Bulletin of the Museum of Comparative Zoology, xx, No. 33, November, 1890, Professor Scott figured and named a large humerus from the Loup Fork of Kansas, under the name (?) *Felis maxima*. The figures given by him show a striking resemblance to the humerus here figured, the other two views of which are given. But the differences in measurement preclude the possibility of their both belonging to the same species, *F. maxima* being at least one-fourth larger. Scott referred the humerus to *Felis* because of the entepicondylar foramen, and not to *Smilodon*. However, I believe that *Smilodon necator*, the species he mentions, is the only known felid in which this foramen is absent, so that there is no objection to placing it in either *Smilodon* or *Machærodus*. In the following measurements, I copy those given by Scott of *Smilodon necator* and *Felis maxima*. The measurements of *Felis leo* are taken from the skeleton of a male nearly adult in the University Museum:

| | *S. necator.* | *F. leo.* | *F. maxima.* | *M. crassidens.* | *Dinotomius.* |
|---|---|---|---|---|---|
| Length of humerus | 384 | 290 | 429 | 313 | 240 |
| Thickness of distal end | 87 | 52 | 72 | 48 | 30 |
| Width of distal end | | | | 79 | 73 |
| Antero-posterior diameter proximal end | | 86 | 118 | 84 | |
| Length of radius | | 260 | | 258 | |
| Greatest diameter of head | | 44 | | 40 | 31 |
| Least diameter of head | | 23 | | 28 | 20 |
| Greatest diameter distal extremity | | 60 | | 58 | |
| Width of shaft at middle | | 25 | | 30 | 25 |
| Length third metatarsal | | 125 | | 125 | |
| Width proximal end | | 25 | | 22 | |
| Depth of proximal end same | | 35 | | 33 | |
| Length fifth metacarpal | | 120 | | 72 | |
| Length of tibia | | 270 | | 194 | 234 |
| Width proximal extremity | | 80 | | 57 | 61 |
| Width distal extremity | | 60 | | 40 | 41 |

(?) **Mylodon harlani** Leidy.

Some time ago Mr. McLaughlin, editor of the Berne Press, sent to the museum a bone of considerable size which had been obtained sometime previously from a well in Seneca of this State. The bone was so robust and peculiar that it was some time before I recognized its true character. Comparison with the figure and description of the tibia of *Mylodon harlani* given by Leidy in the second volume of the transactions of the Wagner Free Institute of Science renders it very probable that it belongs with that species, which has been found in Missouri. The bone was taken from about thirty feet below the surface, in alluvium. Because of the rarity of edentate remains in this state, I have thought it desirable to figure the specimen.

Fibula of *Mylodon* (?) one-third natural size. Internal view.

The surface for articulation with the tibia looks upward, inward and backward, and is elongate oval in outline, nearly flat transversly and gently concave longitudinally. The shaft near the middle is ovate in shape, with the posterior margin

Fibula of *Mylodon* (?) one-third natural size. External view.

thinner. Beginning on the anterior (?) margin near the middle of the bone there is a pronounced roughened ridge which winds to the back and terminates near the distal extremity. On the inner side of the distal third fourth of the bone is the flattened oval articular surface for the tibia, looking upward and inward. Below this toward the front of the bone is a smaller, rounded, flattened articulate surface, looking inward and slightly downwards, for articulation with the astragulus; back of this surface is a large rounded, roughened, depressed surface for the attachment of ligaments.

For *M. harlani*, Leidy gives the total length of the tibia as 233 millimeters, and that of the fibular border as 183 millimeters. The length of the present bone from the top to the lower end of the distal tibial articulation is 210 mm., which is rather large for the length which he gives. His figures for the proximal tibial articulation, 64 and 34 mm., are not disproportionate. Possibly it representsa different species, though hardly a different genus. Below are given the chief measurements of the Kansas specimen.

| | |
|---|---|
| Length | 290 m.m. |
| Greatest diameter proximally | 117 |
| Length of tibial articular surface | 78 |
| Width of same | 32 |
| Antero-posterior diameter of shaft | 50 |
| Thickness same place | 35 |
| Greatest width distally | 80 |
| Greatest thickness at lower end of tibial articulation | 65 |
| Greater diameter of astragular articular surface | 44 |
| Lesser diameter same surface | 33 |

# Cnephalia and its Allies.

BY W. A. SNOW.

"Diese Gattung bedarf einer Revision. Für *Cnephalia* hat der Name *Spallanzania* Rond. einzutreten"*—A not inappropriate text for some observations on the characters assigned to these genera by Messrs. Brauer and Bergenstamm.

Let us first review the history of *Cnephalia* and *Spallanzania*.

In 1830 Robineau-Desvoidy divided the old genus *Gonia* into several genera founded on slight differences of the antennal joints.† One of these, *Spallanzania*, he separated from two others as follows: "Characters of *Rhedia* and *Reaumuria*: antennæ placed in a little deeper depression, second joint longer than in *Rhedia* and shorter than in *Reaumuria*; second joint of arista straight. Facial ridges not ciliate; color black." He described two species, *picea* and *gallica*, of which the first is unknown and the second is a synonym of *Gonia hebes* (Fall.) Meig., Schin., Zett., Kowarz, et al.

The genus *Cnephalia* was erected by Rondani with *hebes* as the type species.‡ He redefined *Spallanzania* and described several species having the third antennal joint twice as long as the second, while in *Cnephalia* the third joint was scarcely as long as the second; and having the second aristal joint elongate, while in his *Cnephalia* species it was very short.

Schiner, who examined typical examples of *Cnephalia* received from Rondani. retained the genus, but recognized in *hebes* not the *hebes* of Fallen, but *Tachina bucephala* Meigen. He therefore regarded *Cnephalia bucephala* as the type of the genus. He speaks thus positively: "Sonderbarer Weise ist seine typische Art: *C. hebes* Meigen von Rondani verkannt worden, und in der That nichts Anderes als *Tachina bucephala* Meigen" § "The true *hebes* Fallen, Meigen," he restored to *Gonia*. The part of Rondani's Prodrome which contained the recharacterization of *Spallanzania* Rob.-Desv. was published about the same time as volume I of Schiner's Fauna Austriaca, and it is probable that the latter author had not seen it, since he mentions the genus only in the sense of Robineau-Desvoidy.

* Brauer and Bergenstamm, Muscaria Schizometopa, Pars. II, p. 353.
† Myodaires, p. 79-82.
‡ Ditt. Ital. Prodr.. III, 59.
§ Fauna Austr. I, p. 445.

Kowarz, in a review of the European species of Gonia* adds to the synonymy of *Gonia hebes*, *Spallanzania cognata* Rond., and *S. alpestris* Rond. He does not mention Rondoni's *hebes*, which would indicate that he agreed with Schiner that it was *Cnephalia bucephala* Meig. He says in his introduction that the genus *Spallanzania* R.-D., which in distinction from *Gonia* Meigen was founded upon the shortness of the second joint of the arista, is not tenable, because of the inconstancy of this character; and credits Dr. Williston with having previously make a similar observation regarding the inadequacy of this character for separating species.†

Van der Wulp about this time made a strenuous attempt to clear away the obscurity surrounding the species *hebes*, when he declared‡ that *Gonia hebes* (Fallen) Meigen, *Cnephalia hebes* Rond. and *C. bucephala* Schiner (non Meigen) were synonyms, and called the species after Rondani, *Cnephalia hebes*. Thus, though Schiner stated positively that Rondani did not have the true *hebes*, but instead *bucephala* Meigen, v.d.Wulp believes that Rondani was correct and that Schiner, besides misconstruing *bucephala*, was guilty of distributing specimens of the same species to different genera. What a blessing to the poor muddled student of today if this synonymy could be accepted without question! But, alas, the researches of later writers have only added to the confusion.

Brauer and Bergenstamm, during the writing of their recent great work, have been induced to change their minds several times in regard to the ill-fated *hebes*. They first follow § Schiner and recognize *Cnephalia bucephala* (Meigen) Schiner as a valid species and the type of the genus. Later, || an examination of the specimens under that name in the Schiner collection results in assigning them to three different species, as follows: *C. multisetosa* Rond., *C. bisetosa* B. B. nov. and *Spallanzania hebes* Rond. A male to which they gave the first name has the second aristal joint but little longer than broad, and the third antennal joint shorter than the second. A female, the type of *bisetosa*, has a similarly shortened second aristal joint and the third antennal joint one and one-third times the length of the second. The third form is referred to *Spallanzania* because the second aristal joint is three or four times as long as thick, and the third antennal joint is twice as long as the second. In this last species they recognize the *hebes* of Rondani. It then follows that *hebes* Rond. is distinct from *hebes* Fall. and the former, which was the type of *Cnephalia*, does not belong to that genus, but to *Spallanzania* in the sense of the author

* Wien. Ent Zeit. vii, Jan., 1888, p 1.
† North American Tachinidæ. Canadian Entom. xix, p. 6.
‡ Biol. Centr.-Amer Dipt. II, p. 45.
§ Mus. Schiz. Pars I, p 109, 1889.
|| L. c. Pars II, p. 353, 1891.

of *Cnephalia! Hebes* Fallen, placed in *Gonia* by Meigen, Schiner, Kowarz and v.d.Wulp, is removed by Brauer and Bergenstamm * to their new genus *Pseudogonia*, the type of which is *Gonia cinerasens* Rond. This genus is distinguished † from *Gonia* by the elongated claws and pulvilli, and the lack of orbital bristles in the male. It is said to differ from *Spallanzania* Rond. only in these very feeble characters: arista geniculate, second joint almost as long as the third; while to *Spalanzania* are imputed: arista not geniculate, second joint much shorter than the third. These statements, based upon a minute analysis of Schiner's specimens, are apparently decisive, and we are hardly prepared for the later declaration of Brauer and Bergenstamm, at the end of Part III, in a supplement to the alphabetical index to Part II, that "*hebes* Fallen (*Gonia*)=*Cnephalia bucephala* Schiner, teste P. Stein. Type Fallen Coll. Lund.=*bisetosa* n." It would seem that the authors omitted *pt.* after the name *bucephala* Schiner. Otherwise it would appear that *Gonia* (*Pseudogonia*) *hebes* Fall. is a "Mischart" of the three species above mentioned, as stated by these authors. If *parte* be inserted, the synonymy would read *Gonia hebes* Fall.=*Cnephalia bisetosa* B. B., which, after all, bears a very decided resemblance to that slighted synonymy of v.d.Wulp's: *hebes* Fall.=*hebes* Rond.=*bucephala* Schiner.

To sum up briefly:

In 1851 Rondani called *Gonia hebes* the type of his genus *Cnephalia.*

In 1862, Schiner declared that *hebes* Rond. was not *hebes* Fall., but a synonym of *bucephala* Meig.

In 1888 v.d.Wulp made *hebes* Rond. and *bucephala* Schin. (non Meig.) synonyms of *hebes* Fall.

In the same year Kowarz did not mention *hebes* Rond. in a treatise on *Gonia*, and the inference is that he agreed with Schiner.

In 1889, Brauer and Bergenstamm followed Schiner in considering *hebes* Rond. as a synonym of *bucephala* Meig.

In 1891 the latter authors placed *hebes* Fall. along with *cinerascens* Rond. in their new genus *Pseudogonia*, and maintained that *C. bucephala* Schin. was in reality equivalent to three species: *C. multisetosa C. bisetosa* B. B., and *Spallanzania hebes* Rond.

In 1893, the same authors in Part III, p. 222, give this synonymy: *hebes* Fallen=*bucephala* Schiner=*bisetosa* B. B.‡ and place the species in the genus *Cnephalia* instead of *Pseudogonia*.

It need hardly be said that few other species in the family have been so misunderstood and received so many names as has the pres-

* L. c. Pars II. p. 404.
† L. c. Pars III. p. 125. 1893.
‡ On p. 125 of the same part, *bisetosa* is spoken of as a distinct species.

ent one. Six generic and eight specific names have been applied to it. The genera are the old composite genus *Tachina*, *Gonia*, *Spallanzania*, *Isomera* R.-D. (=*Gonia*), *Cnephalia* and *Pseudogonia*.

As a further introduction to a discussion of some of the generic characters used to distinguish *Gonia* and related genera, I will insert a slightly modified translation of Brauer and Bergenstamm's table of their Section Gonia as follows:—

Head swollen, front and cheeks broad, ocellar bristles reclinate, arista distinctly three jointed, often geniculate, the second joint more or less elongate; vibrissæ not ascending above the middle of the face; first posterior cell ending before the tip of the wing. Section Gonia.

1.—Proboscis normal .......................................... 2
Proboscis strongly elongate, setiform....... Rhynchogonia B. B.

2.—Claws of male and female short; arista distinctly three-lointed, geniculate, two orbital bristles in each sex; third joint of antennæ in each sex longer than the second...... Gonia Meigen.
Claws of male elongate, sometimes only of the front feet...... 3

3.—Arista geniculate, first joint short, second elongate, almost as long as the third; no orbital bristles in the male, in the female two.................................. Pseudogonia B. B.
Second joint of the arista much shorter than the third, arista rarely geniculate (female).................................. 4

4.—Orbital bristles in each sex two............. Onychogonia B. B.
Orbital bristles in the male none, in the female two; second joint of the arista much shorter than the third, arista not geniculate, 5

5.—Third joint of antennæ twice as long as the second; second joint of the arista three or four times longer than wide. Spallanzania Rond.
Third joint of antennæ shorter than the second (male), or a little longer (male, female). Second joint of arista hardly longer than wide, a little thickened................ Cnephalia Rond.

He also adds that *Eucneahalia* Towns. is near *Spallanzania* if it has reclinate ocellar bristles. An examination of the type shows that these are present.

## GONIA.

With regard to the characters assigned above to *Gonia*, the first one which is given the distinctive position in the table, is by no means constant, as has been observed by Williston in the work previously cited on *Gonia*, wherein he says, speaking of *Gonia exul* Will., that certain males from California which he could not separate, had the claws and pulvilli very large. I have these specimens now before me, as well as other long-clawed males from Estes Park, and Manitou Park, Colorado, of the same species. The species has the third

antennal joint about five times as long as the second, the second aristal joint longer than the third and strongly geniculate; and with but two marginal macrochætæ on each of the first two segments of the abdomen Moreover, several males from the Magdalena Mts., New Mexico, have strikingly elongate claws and pulvilli, but otherwise agree with the types of *Gonia sequax* Will. Dr. Williston, in an article on *Belvosia* * has shown in drawings of the front feet of nine specimens a great variation in the length of the claws in both sexes. *Belvosia* is an allied form and the comparison is pertinent. It would appear to me that the protuberant front is a more available character for the genus *Gonia*.

## CNEPHALIA.

The relationship between *Cnephalia* Rond., *Pseudogonia* B. B. and *Spallanzania* in the sense of Rondani, and Brauer and Bergenstamm, must be a very intimate one. By consulting the table of genera, it will be seen that *Cnephalia* and *Spallanzania* differ from *Pseudogonia* in having the arista straight, and a longer second aristal joint. *Cnephalia* differs from *Spallanzania* only in the third antennal joint being shorter in proportion to the length of the second, and in a shorter second aristal joint. The study of a large series of American "Goniidæ" convinces me that these characters, including the geniculation of the arista, are entirely too variable and unreliable for the differentiation of the genera of the group. This, I trust, will be apparent in the descriptions further on. While I, unfortunately, have not seen European specimens, my opinion, based upon the American material and a study of the European literature, is that *Pseudogonia* and *Spallanzania* must be included in *Cnephalia*.

In the University collection there are specimens which I have assigned to *Cnephalia* under three species. A study of these will explain why I have rejected certain characters regarded as generic by many writers, and which I believe are not even of specific value. The three forms have in common the following characters: Robust form and cinereous color; head broad, a little swollen in front, but much less so than in all the species of *Gonia* which I have seen; front and sides of the face wide, both of which are of nearly equal width in the female, but the former narrowed above in the male. Ocellar bristles reclinate; orbital bristles wanting in the male, but present in the female; two rows of bristles on each side of the front; sides of face beset with small bristles; first two joints of the antennæ reddish, third joint black; arista three-jointed; proboscis long and slender with small labellæ; palpi cylindrical, slightly enlarged at the tip, yellow. Thorax with four black stripes; scutellum testaceous.

* Insect Life, v, p. 238.

Abdomen with broad, cinereous pollinose bands and blackish reflections; first segment without marginal bristles (rarely aborted ones in the male); second segment with two marginal bristles; third segment with a marginal row. Claws of male elongate; tibia of hind legs on the front side with a fringe-like row of bristles, a little longer on the basal half. First posterior cell open, ending before the tip of the wing.

**Cnephalia pansa** n. sp.

Female. Thickly cinereous pollinose, with a faint yellowish tinge. Front and face almost equally wide, the former very slightly narrower, one-half the width of the head; silvery pollinose; frontal stripe brownish; in addition to the frontal bristles there are many dark hairs, especially near the vertex, and a row of very small bristles along the orbits. Sides of faces silvery pollinose, as wide as the depression, beset with many small, irregularly arranged bristles. Facial ridges bare, except for some weak bristles above the vibrissæ, which extend from one-fourth to one-half the distance to the base of the antennæ. The ground-color of the face, and less preceptibly of the front, except near the eyes, is testaceous, which is most apparent at the facial depression and at the epistoma. Third joint of antennæ sometimes reddish at the immediate base, equal in length to the second, or from one-fourth to three-fourths longer than the second. Arista sometimes straight, but usually geniculate, though rarely are the two aristas of a specimen bent at the same angle; second joint of the arista from one to three times its width in length. Sides of abdomen sometimes reddish or luteous; tip of abdomen red or not.

Nineteen specimens, Las Cruces, New Mexico (Coll. Towns., July 9—28).

Three males, Las Cruces, New Mexico (Coll. Towns., May 8) Magdalena Mts., New Mexico (F. H. Snow, Aug. 9500 ft.), Western Kansas have the third antennal joint slightly more than twice the length of the second and the second aristal joint three to four times its own width; the front perceptibly narrowed toward the vertex where it is more than one-third the width of the head. Though two of these specimens show two weak median macrochætæ on the first abdominal segment, I do not doubt that they are conspecific with the females and the other male.

Length, 10—12 mm.

This species differs from Shiner's descriptions of *Cnephalia hebes* and *C. americana* * in having the bristles on the sides of the face arranged irregularly (not "reihenweise geordnet"); and from

* Reise der Novara, p. 327.

Kowarz's description of *hebes* in having five cinereous stripes on the thorax instead of four. The female, too, is often testaceous on the sides and tip of abdomen.

**Cnephalia ruficauda** Towns.

*Pseudogonia ruficauda* Towns. Canad. Entom. XXIV. p. 66.

*Pseudogonia obsoleta* Towns. l. c.

Male and female. In appearance markedly similar to the preceding. The size is the same, the color is darker owing to a thinner covering of cinereous pollen. Front widely on the sides brassy-yellow pollinose, bristles much coarser and longer than in the preceding; front of the male one-third of the width of the head, of the female a little wider, in both sexes perceptibly narrowed toward the vertex. The facial depression is wider than in *pansa* and at its widest is nearly one-half of the facial width; its ground color is black above the epistomata directly beneath the antennæ; sides of the face beset with small black bristles arranged in two rows, one of which follows the orbit and the other lies near the facial ridges diverging below towards the orbital row. In the males the third joint of the antennæ is from one and one-third to four times the length of the second joint, with an average of two and one-third times; in the females the third joint is from one and one-half to one and one-third times the second. In the males the second aristal joint is from three to six times as long as wide, with an average of four times; in the females it is from two and one-half to three times its width. In both sexes the arista may be strongly geniculate or not at all, or the arista of one antenna may be geniculate, while that of the other antenna may be perfectly straight; the arista is generally incrassate in the male and feebly so or not at all in the female. In the males the bristles of the facial ridges ascend above the vibrissæ from five-tenths to eight-tenths the length of the ridges, with an average of six-tenths; in the females they ascend from three-tenths to six-tenths the length of the ridges, average four-tenths. Both sexes vary as to the amount of red on the fourth abdominal segment, a few specimens showing not a trace and others a narrow ring at the tip, while not infrequently the ground color of nearly the whole segment is red.

Ten males and two females, Illinois (Prof. Forbes, Nos. 14,504, 14,566, 14,460—Coll. Townsend), seven males and one female, Southern Illinois (Charles Robertson, Nos. 1630, 1634, 2922, 5444, 6430, 6432—Coll. Williston); one male, Riley county, Kansas, (F. A. Marlatt, in June—Coll. Towns.); two females, White Mountains (Williston); one female, Newton, Mass., (Williston, in July); one male, North Carolina, (Coll. Williston); one male, New York, (Comstock); two males, Brookings, South Dakota, (Aldrich).

One of the males from South Dakota is the type of *Pseudogonia ruficauda* Towns.; the male from New york is the type of *P. obsoleta* Towns.; the male from Kansas bears the label *Acroglossa hesperidarum* Will. (See below, *Acroglossa*) Concerning the type of *obsoleta* Prof. Townsend says: "[It] differs chiefly [from *ruficauda*] in the anal segments being wholly black at tip, not at all rufous; the third antennal joint blackish, rufous at base, arista brown."

**Cnephalia finitima** n. sp.

Four males and six females from Las Cruces, N. M. (Coll. Towns., July 3—Sept 20) were at first confounded with the preceding species, which they greatly resemble. However, they differ in the much smaller size of the frontal bristles, the greater width of the front and the sides of the face, and correspondingly narrower facial depression. *C. ruficauda* has a bright brassy color on the sides of the front, while in the present species they are cinereous with a slight yellowish or brownish tinge. The third joint of the antennæ in the males varies in length from two to two and a half times the length of the second joint; in the females from one and one-third to one and two-thirds the length of the second. The second joint of the arista varies in the males from three to six times its own width; in the females from one and a half to five times its width. The bristles of the facial ridges ascend in the male from one-half to three-fourths the distance to the root of the antennæ; in the females from three-tenths to six-tenths. Two of the males show no red on the fourth abdominal segment, while all of the females show at least a narrow margin of red at the tip. The arista in both sexes may be geniculate or not; it can hardly be called incrassate, except in one of the males. A single male has a weak marginal bristle on the first segment.

Thus from examination of my material in these Gonia-like genera it appears that the third antennal joint is generally much shorter, and the second joint much longer in the female than in the male; the second aristal joint is not as long in the female as in the male, and the cilia of the facial ridges reach higher in the male than in the female. It is also seen that some males may have much shorter ungues than other males of the same species.

I feel no hesitancy in declaring my belief, formed in the study of other groups of this family, before examination of these specimens, that the relative length of the antennal joints, the relative length, the width and the degree of geniculation of the aristal joints, the extent to which the facial ridges are invaded by bristles, the presence or absence of a sparce ocular pubescence and the closure of the first posterior cell at or near the margin of the wing, are characters which

are at best of secondary importance in the separation of species, and inconsequential in the extreme in the separation of genera. The character derived from the length of the claws must also be used with very great caution.

On such inadequate characters many genera have been established by recent authors. As a result a beginner is often in doubt whether he has before him a male and female of a species of *Phorocera*, or *Cnephalia* for example, or has representatives of two different genera belonging to two subfamilies.

## EUCNEPHALIA.

The genus *Eucnephalia* Towns., placed in the "Phoraceratinæ" by the author, probably belongs to this group, as suspected by Brauer and Bergenstamm. The typ especies, *gonioides*, differs from other species of the group which I have seen in its short proboscis, furnished with rather thick labellæ. Its first abdominal segment bears a pair of strong marginal bristles; the third antennal joint is at least four times as long as the second; the second aristal joint is hardly two times as long as it is wide. The bristles of the facial ridges ascend a little above the middle of the face. The ocellar bristles are reclinate.

## ACROGLOSSA.

The genus *Acroglossa* Williston * has been confounded with *Spallanzania* by Messrs. Brauer and Bergenstamm † who have misunderstood the direction of the ocellar bristles in the figure given by the author. They are directed forward and outward in both sexes, as stated in the description. Giglio-Tos‡ has recently described a Mexican species, which he refers to *Acroglossa*. It is interesting to note that the ocellar bristles in his species are proclinate. Brauer and Bergenstamm's further statement (l. c.): "The genus cannot be compared with *Fontina* on account of the lack of ascending bristles on the facial ridges," is also expressly contradicted in both description and plate. It is therefore evident that these last named authors had no example of the genus before them. Had they had specimens with proclinate bristles, so great is their respect for this character, they would certainly have located the genus in another group.

In the Townsend Collection is a specimen of *Cnephalia ruficauda* Towns. bearing Prof. Townsend's label "*Acroglossa hesperidarum* Williston" and the locality label "Riley Co., Kans." It is doubtless the one spoken of by him in Trans. Amer. Ent. Soc. xviii, p. 367, as

* Scudders Butterflies of New England, p. 1916.
† L. c Pars. ii. p. 351.
‡ Ditt. del Messico, Pars. iii, 1894, p. 34.

agreeing with Dr. Williston's description. This insect, however, differs from *Acroglossa* in the direction of the ocellar bristles, which are turned backwards; otherwise it seems to agree well with the description of *A. hesperidarum*. Brauer and Bergenstamm place much stress on this character. To illustrate, they erect the genus *Cnephaliodes* for the reception of a specimen which was a *Cnephalia* in all respects except the direction of the ocellar bristles. In the present instance I do not know whether *Acroglossa* should be united with *Cnephalia* or not. Though I have not seen the types of *Acroglossa*, it is evident from the description that this ocellar-bristle character is all that separates the two genera. In my experience, this character is not a variable one. I find but three specimens in the series of Cnephalia-like forms which have the bristles proclinate, and these have also short, stout proboscides, with large labellæ. In *Gonia* these bristles are regularly curved backwards.

In conclusion, what has been said in the foregoing pages will at least indicate how much we have yet to learn before we can correctly appreciate the relative values of the structural characters of the Tachinidæ. To the non-dipterological entomologist it may seem surprising that the presence or absence of a mere bristle, or even the direction toward which a bristle is turned may serve to distinguish not only species and genera, but even groups of genera, but the student of Tachinidæ is almost prepared to base species and genera upon a single hair.

# A New Species of Pelecocera.

BY W. A. SNOW.

The three genera of Syrphidæ whose antennæ have a terminal style instead of a dorsal bristle or arista, are *Ceria* Fabr., *Callicera* Panz., and *Pelecocera* Meig. Of the latter, four European species have been described. One of these, *P. scævoides* Fall. differs from the other members of the genus in that its antennal bristle is dorsal instead of terminal, and not stilliform. The only American species hitherto known is *P. pergandei* Will.,* which has a thick three-jointed terminal style. Recently collected specimens from New Mexico, belonging to a new species, agree in antennal structure with *scævoides* and suggest the advisability of forming a new genus founded upon *scævoides* and *willistonii*.

**Pelecocera willistonii** n. sp.

Female. Black, shining. Head concolorous. Front one-third the width of the head, with a shallow horizontal depression at the middle; pile whitish at the vertex, below a little dusky; sides beneath the depression, silvery pollinose. Antennæ reddish-yellow, black on the upper edge of the third joint; first two joints small; articulation of the second and third joints above the middle of the latter; third joint round, plate-shaped; arista black, arising from the middle of the dorsal edge of the joint, comparatively slender, thickest at base, indistinctly jointed, pubescent. Face at the sides yellow, silvery pollinose; in the middle shining black; concave beneath the antennæ, then broadly convex below, descending a short distance beneath the eye; cheeks brownish. A silvery pollinose spot on the humeri which extends to the base of the wings; scutellum with two weak sub-apical black bristles. Abdomen brownish black, shining, immaculate, long, narrower than the thorax. Legs yellow, covered with short silvery pile; hind femora broadly infuscated in the middle. Pile of the whole body sparse and white. Wings hyaline, stigma dilutely yellow.

Length 5 mm.

This species is distinct from the European *scævoides* in its unicolorous abdomen.

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*Synopsis of N. A. Syrphidæ, p. 110.

# Exotic Tabanidæ.

BY S. W. WILLISTON.

**Pangonia venosa** Wiedemann, Auss. Zw. Ins. i, 87.—Brazil.

Two male specimens from Rio de Janeiro. The wings are wholly dark brown.

**Pangonia fulvithorax** Wiedemann, Dipt. Exot. 152; Auss. Zw. Ins. i, 89. —Brazil.

Male. Ocelli present. Eyes hairy. Antennæ slender, the second to the seventh annuli of the third joint of nearly equal length, the eighth as long as the three preceding together, gently tapering; first two joints black, with black hair; the third reddish yellow. Face conical, dark brown, slightly dusted with sparse black hair. Palpi slender, nearly black. Proboscis nearly as long as the head and thorax together. Beard dark brown, yellowish on the orbits above. Mesonotum and scutellum dark cinnamon brown, thickly covered with light yellow hair, Pleuræ and pectus dark brown with brown hair. Abdomen broad and thickset, dark shining brown, broadly covered with recumbent golden hair on the sides posteriorly. Legs nearly black, with black hair. Wings dark brown; first posterior cell closed before the border of the wing. Length 19 mm.

Two specimens, Rio de Janeiro, H. H. Smith.

**Pangonia unicolor** Macquart, Dipt. Exot. Suppl. 1, 55, pl. iii, f. 6.—Brazil.

Numerous specimens. The antennæ are slender, the third joint but little expanded at the base, the second to the seventh annuli of the third joint of nearly equal length, the eighth as long as the three preceding together. The face is conically produced. The second joint of the palpi is as long as the third joint of the antennæ, and is slenderly crescentic in shape. A rudiment of a vein is present on the anterior branch of the third vein, but the first posterior cell is open. The proboscis is long, and the labium is coiled up within the buccal cavity, admitting of great extension.

**Pangonia pyrausta** Osten Sacken. Biol. Centr. Amer. Dipt. i, 43.—Mexico.

A single female specimen from Mexico agrees in all respects with the description of this species, save in the absence of the mesonotal stripe and the white hair of the abdomen, and in the third joint of antennæ being ferruginous.

**Pangonia diaphana** Schiner, Reise der Novara, Dipt. i, 43. Chile

Two specimens from Brazil, agreeing well with the description. The palpi are long and slender; the basal annulus of the third antennal joint is thickened, and the last is long and style-like.

**Pangonia arcuata**, n. sp.

Eyes bare. Ocelli present. Front narrow; dark ochraceous, with a slender dark line in the middle. First two joints of the antennæ yellow, the third yellowish red; third joint considerably dilated at the base, the eighth annulus long, style-like. Face mostly yellowish in ground-color, lightly dusted, receding in profile. Palpi yellow, the second joint much elongated, arcuate and porrect, extending as far forward as do the antennæ. Proboscis stout, scarcely as long as the thorax, black. Mesonotum yellow, but little shining, thinly yellowish and blackish pilose. Pleuræ densely white pollinose and with white pile. Abdomen moderately elongated, shining, thinly black pilose, except on the hind margins of the segments where it is white: first segment light translucent yellow; second segment yellow with the anterior margin in the middle more or less brownish; third segment dark brown with the hind margin yellow; remaining segments nearly black, with the hind margin narrowly pallid yellow. Legs yellow, the hind tibiæ and tarsi for the most part brown. Wings tinged with brownish, in front yellowish; anterior branch of the third vein with a long stump; first posterior cell closed. Length 14 mm.

Two specimens, Chapada, Brazil, H. H. Smith.

**Pangonia filipalpis**, n. sp.

Eyes bare. Ocelli present. Front narrow; yellow, with a slender, denuded streak. First two joints of the antennæ yellow, the third orange-red; basal segment broad, the annulate portion slender, the terminal annulus long, style-like, as long as the preceding four annuli together. Palpi yellow, the second joint long, slender and arcuate. Proboscis stout, a little longer than the vertical diameter of the head, black, the labella short. Face receding in profile, covered with yellowish dust. Beard scant, nearly white. Mesonotum deep brown or black beneath the yellowish dust, forming three broad, nearly confluent stripes and leaving the lateral margins yellow. Pleuræ brown and yellowish, with white pile. Scutellum nearly black, whitish dusted. Abdomen elongate; first segment light yellow, with a black spot beneath the scutellum; second segment light yellow, with a black spot in the middle in front; third segment black, with the hind part yellow, the immediate margin pallid yellow; the remaining segments black, with a palid yellow hind margin. Legs black. Wings tinged

with brown, in front yellowish; anterior branch of third vein with a long stump; first posterior cell closed. Length 17, 18 mm.

Two specimens, Rio Paraguay, December, H. H. Smith.

**Pangonia bullata**, n. sp.

Female. Eyes bare. No ocelli. Front very narrow, the eyes nearly contiguous. Head and thorax black throughout. Face receding in profile. Palpi stout. Third joint of antennæ opaque deep black, not slender. Proboscis short. Thorax shining, with black hair. Abdomen inflated, black, with three broad red stripes, the medium one beginning beneath the scutellum, the others on the lateral margins. Venter red on the sides. Legs black. Wings deep brown; anterior branch of the third vein with a stump of a vein; first posterior cell closed. Length 17 mm.

One specimen, South Africa.

**Pangonia margaritifera** Wiedemann, Auss. Zw. Ins. i, 88.—"Austral-Asia."

*Tabanus guttatus* Donovon, Gen. Illustr. Entom.; Wiedemann, op. cit.

A single specimen from Queensland, agreeing closely with Wiedemann's description.

**Chrysops intrudens**, n. sp.

Female. Front opaque light yellow, the vertical callosity brown, the frontal callosity oval, and shining amber-yellow. Antennæ slender, as long as the mesonotum, yellow, the second joint partly and the third joint wholly brown. Face light shining reddish yellow, opaque yellow on the sides and above. Mesonotum deep brown, with four opaque yellow stripes, of which the inner pair are connected by a yellowish, somewhat variable dust in front, where the stripes themselves are narrow. Pleuræ nearly black, with opaque spots. Scutellum red, shining. Legs yellowish red, the front and hind tibiæ, the front tarsi and the distal joints of the posterior tarsi brown. Wings brown with the following hyaline spots: the distal portion of the first and second basal cells, the anal cell, a triangle on the hind border in the fifth posterior cell and another in the second posterior cell extending into the third; the anal angle is subhyaline. Abdomen: first segment wholly light yellow; second segment light yellow with two black triangles, their apex in front; third segment black or dark brown with a median yellow stripe; fifth and following segments black or brown with three narrow yellow stripes. Length 8 mm.

Male. First antennal joint a little thickened. Mesonotum darker colored, the inner pair of stripes not connected by yellowish dust. Abdomen black, the first segment on the sides, the broad anterior angles of the second segments, a slender median stripe beginning on

the second segment, and a slender lateral stripe distally, light yellow. Hyaline spots of the basal and posterior cells smaller.

Three females and one male, Chapada, Brazil.

**Chrysops varians** Wiedemann, Auss. Zw. Ins. i, 208.—Brazil.

Male. Face light gray, the callosities shining yellowish brown. Antennæ elongate, nearly as long as the mesonotum, the first joint incrassate; yellow, the third joint brown. Thorax black; mesonotum with two slender median stripes and a broader lateral margin, opaque gray. Abdomen black or deep brown; second segment with the anterior angles yellow and three gray spots on the hind margin; third and following segments with a gray hind margin. Legs dark brown; the metatarsi yellowish. Wings dark brown; a hyaline spot across the outer part of the basal cells, another in the anal cell, a triangle in the fifth posterior cell, and the whole apex of the wing, except a border along the costa to the extreme tip, hyaline; anal angle subhyaline.

Female. Front with a very broad callosity; face mostly shining. Mesonotum less darkly colored, the stripes broader, and the inner pair nearly connected in front by a bluish gray pruinosity. Abdomen brown; angles of the second segment more broadly yellow, and the median gray triangle behind much larger. All the basal cells of the wings hyaline (the veins at the ends clouded only); fifth posterior cell more largely hyaline. Length 8 mm.

Three females and two males, Chapada, Brazil.

**Pelecorhynchus ornatus** Schiner, Reise der Novara, Dipt. 78.—Auckland.

One specimen, Queensland, agreeing well with the description.

**Selasoma tibialis** Fabricius, Syst. Antl. 102 (*Tabanus*); Wiedemann, Dipt. Exot. i, 89 (id.); Auss Zw. Ins. i. 165 (id.); Macquart, Dipt. Exot. i, 2.—South America (Wied.), Brazil (Macq.).

A number of specimens from Chapada, Brazil. I quite agree with Schiner that the differences between this genus and *Hadrus* Perty are trivial.

**Hadrus lepidotus**, Wiedemann, Auss. Zw. Ins. i, 193 (*Tabanus*); Perty, Delectus, etc. 183, pl. xxxvi, f. 9; Macquart, Dipt. Exot. i, 1, 154, pl, xviii, f. 3 (*Lepiselaga*); Schiner, Reise der Novara, Dipt. 96.—South America, West Indies, Mexico.

Several specimens from Brazil.

**Hadrus parvus**, n. sp.

Female. Face, cheeks, and the callosity upon which the antennæ are situated deep black, shining. Front considerably broader below, where the width is equal to the length; for the most part shining black (there is some grayish dust below the vertical callosity and on

the lateral margins). Antennæ ferriginous, the third joint black at the extremity. Palpi dark pitchy black. Thorax shining black, the mesonotum more brown and but little shining, and clothed with yellowish irridescent tomentum. Wings brown and hyaline; the brown extends as far as the tip of the first longitudinal vein, does not quite reach the hind border, and has an angular sinus extending to the fifth vein at the middle of the discal cell; a hyaline spot extends across the fourth vein a little in front of the discal cell. Legs deep brown; the four hind tarsi light yellow, the front metatarsi yellow or yellowish; all the tibiæ dialated. Length 5, 6, mm.

Two specimens, Rio Paraguay, H. H. Smith. This species is at once distinguishable from *S. lepidotus* by the smaller size and wider front. From *S.* (*Hæmatopota*) *crassipes* Wied. it will be distinguished by the single hyaline spot of the wings and the yellow tarsi.

**Diachlorus curvipes** Wiedemann, Auss. Zw. Ins. i, 176 (*Tabanus*); Macquart Hist. Nat. Dipt. i, 208 (*Diabasis*).—South America.

Female. Front a little broader below, light opaque yellow, the prominent vertical tubercle clothed with short black hair, the black or deep brown, shining callosity broader than long. Antennæ red, the third joint blackish distally; second joint not more than one-third the length of the first, the third wholly without tooth. Face broadly swollen in the middle, shining yellowish brown, the orbits and the cheeks opaque yellow. Mesonotum on the sides and in front, and narrowly behind, as also a slender median stripe, covered with golden yellow pile; elsewhere the mesonotum is shining black. Scutellum covered with the same yellow pile. Pleuræ for the most part black, lightly pruinose; in front and below the wings yellow. Abdomen shining reddish or brownish yellow, with a slender median stripe of golden yellow pile. All the femora reddish or brownish yellow; the dilated front tibiæ and the front tarsi dark brown; hind tibiæ for the most part brown; middle tibiæ and their tarsi, except the terminal joints, light yellow. Wings yellowish hyaline, brownish in front, the apex brown. Length 9, 10 mm.

This description does not fully agree with the original, nevertheless there can be little doubt of the identity. Four specimens, Rio Paraguay, Dec., H. H. Smith.

**Dichelacera (Diachlorus?) scutellata**, n. sp.

Female. Front not more than twice as long as its greatest breadth, opaque light gray, with a large triangular callosity whose sides are convex, and which extends to the ocelli. Antennæ yellow, the annulate portion of the third joint black and hairy; first joint four or five times the length of the short, globose second joint, the third joint longer than the first two together; third joint with a minute tooth

above, the annulate portion as long as the basal portion. Face shining yellowish. Palpi brownish yellowish, large, Tabanus-like. Mesonotum polished brown, with two narrow whitish stripes in front; on the posterior part with bright yellow pile (it is possible that the yellow pile may be more extensive in perfectly fresh specimens). Abdomen brown with a median light yellow stripe. Legs brown, the hind tibiæ blackish. Wings hyaline with the anterior border to the apex, a moderately broad band beginning beyond the end of the first vein and extending into the fifth posterior cell, a cloud on the outer part of the third vein and on the posterior basal transverse vein, dark brown; anal angle subhyaline. Length 9, 10 mm.

Four specimens, Chapada, Brazil. I cannot find any description which will apply to this species, nor am I confident where it should belong. It has the elongate form and the elongate first antennal joint of *Dichelacera*, but lacks the prominent process of the third antennal joint. The front tibiæ are slender, wherein it differs from the species of *Diachlorus* known to me.

**Stibasoma theotænia.**

? *Tabanus theotænia* Wiedemann, Auss. Zw. Ins. i, 136; Schiner Reise der Novara, Dipt. 98 (*Stibasoma*).—Montevideo.

Male. Facets of eyes much enlarged on the upper part, small below; eyes bare. No ocelli. Process of third joint much enlarged and reaching as far forward as the non-annulate portion; style short. Face black, lightly dusted. Palpi black, with black pile. Thorax deep black, with black hair; mesonotum lightly whitish dusted above. Abdomen deep shining black throughout, and with black hair only. Legs deep black; front tibiæ dilated; hind tibiæ black-ciliate without and within. Wings deep brown, the apex cinereous hyaline. Length 16 mm.

One specimen, Chapada, Brazil. If this is the male of the true *S. theotænia*, it differs very much in the color of the abdomen, which is given by Schiner as light yellow on the basal segments. As no male has been described in this genus, it is not at all impossible that such sexual differences may exist. That it is neither *S. fulvohirtum* or *S. tristis* is evident from the black wings, and, if the species is not *S. theotænia* it must be new, the female unknown.

**Tabanus.**

There are in my collection numerous species of *Tabanus* from South America, only a part of which I have been unable to identify so far. Notwithstanding this, it is probable that not a few of them have been described, and nothing will be gained by giving names to them now.

**Tabanus festivus**, Wiedemann, Auss. Zw. Ins. i, 135.—Brazil.

One specimen, Chapada. The densely ciliate hind tibiæ, black in front and white behind, renders this handsome species easily recognizable.

**Tabanus T-nigrum** Fabricius, Syst. Antl., 101: Wiedemann, Auss. Zw. Ins. I, 160.—South America.

Two females from Rio de Janeiro, November. The third joint of the antennæ, with its basal process, is very slender. The palpi also are unusually slender. The front tibiæ are brownish at the tip only, and all the tarsi have the three or four distal joints brown.

**Tabanus leucaspis** Wiedemann, Auss. Zw. Ins. i, 170.—Brazil.

Three specimens, Chapada. The basal process of the third antennal joint is a mere tubercle. The palpi brownish, the front tibiæ light yellow on the proximal third, the middle and hind pairs on the proximal half or two-thirds. Eyes bare, ocelli minute. The opaque white scutellum is a conspicuous characteristic of the species.

**Tabanus unicolor** Wiedemann, Auss. Zw. Ins. i, 141.—Brazil.

Two specimens, Uarcarizal, Febr. The third joint of the antennæ is brown, with a moderately elongate basal process. The front is rather broad, wholly without denuded spots and without ocelli. Eyes bare.

**Tabanus importunus** Wiedemann, Auss. Zw. Ins. i, 127.—Brazil.

Three specimens, Rio Paraguay, below Concepcion. The specimens agree with the description, except that the legs are more yellowish, with the tarsi brown or black. The third joint of the antennæ is in some specimens mostly black; its annulate portion is slender, the process above acute, but not produced.

**Tabanus modestus** Wiedemann, Auss. Zw. Ins i, 146.—Brazil.

The third joint of the antennæ in some specimens is wholly reddish yellow; in others with the short annulate portion blackish; its basal process is sub-angulate, not produced. The eyes in the female are wholly bare; thickly and distinctly pubescent in the male. There are no ocelli. In the male, the legs and antennæ are somewhat darker, but there is scarcely any other difference. Eight specimens, Chapada and Rio de Janeiro.

**Tabanus quadripunctatus** Fabricus, Entom. Syst. 99; Wiedeman, Auss. Zw. Ins. i, 150; Schiner, Reise der Novara, Dipt. 86.—Brazil.

A single specimen from Rio de Janeiro seems to be of this species. From Wiedemann's description it differs in not having a very strong tooth to the third joint, and in lacking the "Dornchen" on each side of the vertex. Schiner's description of the abdomen, but not of the legs, agrees better. All the tibiæ are blackish distally. The first posterior cell is narrowly open.

# Chemical Analysis of Counterfeit Gold Dust.

BY V. L. LEIGHTON AND H. P. CADY.

(Read before the Kansas Academy of Science.)

Some years ago one of the Kansas banks bought a quantity of gold dust, which afterwards was discovered to be an exceeding clever imitation of placer gold and was thought to be entirely worthless. A small quantity of it was given one of us a short time ago for analysis when its true character was discovered.

In appearance it very much resembled placer gold, being composed of malleable irregular shaped flakes mixed with a coarse powder; under the microscope this powder was seen to be composed of two substances of different color and general appearance. One of these was identified as Chalcopyrite ($CuFeS_2$), the other was evidently fine turnings of an alloy.

The flakes were entirely unattacked by either nitric or hydrochloric acids, but if treated with nitrohydrochloric acid they immediately lost their yellow color and became white. On further examination these flakes were found to be nearly pure platinum plated with gold. The powder was completely decomposed and partially dissolved by either hydrochloric or nitric acid, giving a blue color to the solution, and leaving a finely divided black residue. To separate the platinum, the mixture was first treated with boiling concentrated nitric acid, carefully washed, and then treated with boiling concentrated hydrochloric acid, and then with cold dilute nitro-hydrochloric acid, which immediately dissolved the gold plating on the platinum and the residue left from the decomposition of the alloy.

In working up the various solutions, it was found that the nitric acid solution contained, besides the other metals, a small quantity of platinum. The solution of the platinum in nitric acid was accounted for by the well known fact that an alloy of silver and platinum is readily soluble in nitric acid. The hydrochloric acid solution contained a comparatively large amount of platinum, 24 grammes being obtained in working up 1000 grammes of the mixture. That this was not due to nitro-hydrochloric acid formed by nitric acid remaining in the residue, was shown by the fact that the gold plating on the platinum was entirely unaffected, and it was found that this dissolved immediately in cold dilute nitro-hydrochloric acid.

As no mention could be found in the literature at our disposal, of platinum dissolving in hydrochloric acid under any circumstances, some experiments were undertaken to explain it. These will be described later.

First it was thought best to make a quantitative analysis of the alloy. This was attended with considerable difficulty, for it was impossible to separate the alloy from the flakes of platinum or the chalcopyrite. It was also impossible to get two similar samples, on account of the peculiar physical nature of the material; so everything had to be determined from the same sample. As the process was somewhat complicated, a brief outline may be of interest.

The mixture was first fused with potassium chlorate, potassium carbonate and sodium chlorid, which oxidized the sulfur in the pyrite to sulfuric acid, which was determined in the usual way as barium sulfate. The residue was then treated with boiling nitric acid which dissolved out most of the iron, copper, nickel, lead, silver, and a little platinum. The residue from this solution was then treated with boiling hydrochloric acid, which dissolved all of the rest of the above-mentioned metals, except a little platinum from the alloy. This was removed from the flakes of platinum by washing, and dissolved in dilute nitro-hydrochloric acid. The platinum not in the alloy remained entirely unaffected as was shown by the gold plating still remaining on it. The gold was then separated from the platinum by treating with a cold dilute solution of potassium cyanid.

In the nitric acid solution the silver was first precipitated by hydrochloric acid. The platinum was then separated by ammonium chlorid, and the lead afterwards precipitated by sulfuric acid. Then the iron was precipitated by ammonium hydrate. The copper was then separated from the nickel by precipitation as cupric sulfid, and weighed as a sulfid, then as a check redissolved and weighed as oxid. The nickel was then precipitated with pure sodium hydroxid, ignited in a stream of hydrogen and weighed as the metal. The metals in the hydrochloric acid solution were separated in the same way. The result of the analysis was as follows:

| | |
|---|---|
| Iron | 4.50 per cent. |
| Sulfur | .57 |
| Silver | 6.08 |
| Lead | 1.37 |
| Platinum, in Alloy | 9.12 |
| Platinum, not in Alloy | 46.41 |
| Gold | .26 |
| Copper | 28.90 |
| Nickel | 2.96 |
| Total | 100.17 per cent. |

The amount of chalcopyrite, calculated from the amount of sulfur was 1.69 per cent. Subtracting this and the gold plated platinum flakes leaves 51.80 per cent of the alloy having the following composition:

| | |
|---|---|
| Iron | 7.67 per cent. |
| Silver | 11.73 |
| Lead | 2.63 |
| Platinum | 17.60 |
| Copper | 54.67 |
| Nickel | 5 70 |
| Total | 100.00 per cent. |

An alloy was made of this composition which resembled gold somewhat in color and was but slightly attacked by dilute nitric acid, but readily by concentrated nitric acid, leaving a black residue.

The specific gravity of the original mixture was 14.43. The specific gravity of native gold is from 15 to 19.6. The specific gravity of the platinum flakes was 21.32. They were evidently made by cutting coarse platinum wire into small pieces and hammering them in an iron mortar.

## Experiments on the Solubility of Platinum in Hydrochloric Acid.

The platinum used in these experiments was pure spongy platinum, prepared by precipitation as ammonio-platinic chlorid, ignition in a stream of hydrogen, and treatment with concentrated hydrochloric acid, which would dissolve any ammonio-pltinic chlorid that might remain.

Exp. 1. 2.65 grammes of platinum was boiled in an open beaker about six hours. The platinum obtained from the solution was .079 grams. This experiment was repeated several times with practically the same results.

Exp. 2. .25 grammes of platinum was sealed in a hard glass tube with one c. c. of conc. hydrochloric acid. This was heated for about three hours to 200 degrees C. .0113 grammes of platinum were obtained from this solution.

Exp. 3. .200 grammes of platinum was placed in a tube with one c. c. of hydrochloric acid and hydrochloric acid gas passed into the tube to expel the air. The tube was then sealed and heated for ten hours from 300 to 360 degrees C. The platinum obtained was .023 grammes.

Exp. 4. One c. c. of hydrochloric acid was placed in a glass tube having a constriction near the open end. .20 grammes of platinum was then introduced a few inches beyond the constriction. Hydrogen was then passed into the tube by a slender tube reaching nearly to the bottom. The platinum was then heated for some time to expel all the oxygen which might have been condensed on the surface. An apparatus for generating hydrochloric acid gas was substituted for the hydrogen generator, and hydrochloric acid gas passed through the tube for some time. The open end of the tube was then closed with a cork and sealed at the constriction. This was heated for twelve hours at from 300 to 360 degrees C. .0045 grams of platinum was obtained from this solution.

These results in tabular form are as follows:

| No. | Amount Taken. Grammes. | Amount obtained. | Per cent. | Time. Hours. | Temperature. |
|---|---|---|---|---|---|
| 1. | 2.65 | .079 | 2.10 | 6 | Boiling. |
| 2. | .25 | .0113 | 4.52 | 3 | 200 C. |
| 3. | .20 | .023 | 10.50 | 10 | 300—360 C. |
| 4. | .20 | .0045 | 2.25 | 12 | 300—360 C. |

These results would seem to indicate that the oxygen of the air plays an important part in the solution, being condensed on the surface of the platinum and then acting on the hydrochleric acid, setting free chlorine, which then unites with the platinum to form platinic chlorid. We think it probable that if all the air could be removed from the apparatus, the platinum would be entirely unattacked. Further experiments with this and other acids will be undertaken.

# The Temperature Sense.

WILLIAM NEWTON LOGAN.

Science is indebted to Messrs. Blix, Donaldson, Eulenberg and Goldschieder for valuable contributions concerning the temperature sense; nevertheless many of the phenomena connected with it remain unexplained, and the future undoubtedly has much to reveal concerning it.

Briefly stated, the facts which have been established by the above scientists are: That there are certain points on the skin which are sensible to cold and certain ones which are sensible to heat; that there are others which are insensible to either heat or cold; and that the destruction of the epidermal layer does not destroy the temperature end-organs. A more complete account of the history of the temperature sense may be found in volume X of *The Mind.*

The following experiments, while not throwing any direct light on the subject, may be of value in the way of suggestion:

The first experiments of the writer were made with a view of locating the temperature spots on different parts of the body. Nothing, however, worthy of notice was discovered, except that I found little to confirm the theory that there are different sets of nerves for different degrees of temperature. End-organs that were sensible to heat were sensible to all degrees of it. Nevertheless I found a great difference in degree of intensity of sensation. For instance, when an end-organ which gave a very strong sensation was found, there would be surrounding it several end-organs gradually shading off in intensity of sensation as the distance from the central organ is increased. These centers I have called radial centers, and in the following experiments have noted the number in each section gone over.

My first thought in reference to this phenomenon was, that there is a central nerve; that from this nerve several others radiate; and that the intensity of sensation decreases as the distance from the central organ increases. But I have found nothing in the science of histology to either prove or disprove it.

In experimenting with the ear, it was found that what at first appeared to be an increased number of cold spots was only hyperæsthesia resulting from frost-bite. I next experimented with scars, but

my experiments served only to confirm the theory of former writers, viz., that the end-organs are not situated in the epidermal layer. Experiments with abnormal growths of the skin indicated no temperature nerves in the wart, but both heat and cold spots in the hair mole near the follicles of the hair.

The instrument which I used in making the experiment is similar to the tube described by Donaldson in his description of Prof. Hall's kinesmeter. It consists of a hollow glass tube with a slightly projecting platinum wire in the closed end. The tube is filled with water, the temperature of which is registered by a suspended thermometer.

While making the above experiments the question occurred to me whether climatic or racial distinctions would show any perceptible difference in the number of the temperature end-organs, or whether, as has been asserted, the end-organs themselves became more or less anæsthetic or hyperæsthetic, according to climatic conditions. With a desire to throw some light upon the question, I began a series of experiments, the results of which are recorded below.

The experiments were made on the left lower arm of the subject between the *anterior ulnar* vein and the *median* vein upon a space one and one-half centimeters by two centimeters, with the instrument described above. I first noted the number of cold spots, next, the number of heat spots, and then the number of spots where the subject made no distinction betwen hot and cold, but would call "hot" for the cold instrument and vice versa. These spots I have called neutral-spots. The number of radial centers mentioned above were noted also. Considerable care was given in the majority of cases, and the space gone over again and again.

My first experiments were with members of the

## Caucasian Race.

| | Cold Spots. | Heat Spots. | Radial Centers. | Neutral Spots. |
|---|---|---|---|---|
| Subject No. 1, b. in Kansas....... | 31 | 15 | 2 | 2 |
| " " 2 " Kentucky.... | 29 | 14 | 4 | 3 |
| " " 3 " New York.... | 30 | 16 | 5 | 3 |
| Average No. in 1, 2 and 3........ | 30 | 15 | 3⅔ | 2⅔ |

Subject No. 4 was paralyzed in left arm. Total analgesia, and anæsthesia. Very slight sensation in what might have been the radial-centers. Less sensitive to heat than cold. Slight anæsthesia of heat-spots found in No. 2, and hyperæsthesia in No. 3.

## American Race.

| | | | | |
|---|---|---|---|---|
| Subject No. 1, b. in Kansas....... | 28 | 17 | 2 | 1 |
| " " 2 " Colorado..... | 31 | 14 | 3 | 0 |
| " " 3 " " ..... | 27 | 16 | 2 | 1 |
| Average...................... | 28⅔ | 15⅔ | 2⅓ | ⅔ |

Nos. 2 and three were members of the same family.

## Ethiopian Race.

| | | | | |
|---|---|---|---|---|
| Subject No. 1, b. in Louisiana..... | 39 | 16 | 3 | 3 |
| " " 2 " Mississippi.... | 36 | 15 | 3 | 1 |
| " " 3 " Kansas....... | 34 | 14 | 2 | 2 |
| " " 4 " Missouri...... | 35 | 16 | 2 | 0 |
| Average...................... | 36 | 15¼ | 2½ | 1⅓ |

Probable hyperæsthesia of cold-spots in No. 1.

## Mongolian Race.

| | | | | |
|---|---|---|---|---|
| Subject No. 1, b. in China........ | 34 | 12 | 4 | 4 |
| " " 2 " " ........ | 32 | 14 | 3 | 2 |
| " " 3 " Japan........ | 29 | 16 | 2 | 3 |
| " " 2 " Philipine Isl... | 30 | 13 | 2 | 2 |
| Average...................... | 31¼ | 13¾ | 2¾ | 2¾ |

Partial anæsthesia of the thermal end-organs noticed in first two subjects, due to their having had their hands in the hot water of the wash-tub a large part of the time. The results of other experiments, which are not given here, in no way conflict with the results given above, but are withheld for the reason that they would add nothing to what has already been stated.

It will be seen, if we are warranted in generalizing from the above results, that the maximum number of cold-spots is to be found in the Ethiopian race, and the minimum number in the American, while the heat-spots reach the maximum number in the American race, and the minimum number in the Mongolian race. If the number of temperature end-organs is in any way effected by climatic conditions, we would expect to find the races standing in the following order, with regard to the maximum number of cold-spots and the minimum number of heat-spots: Ethiopian, Malay, Mongolian, Caucasian and American. The last two, however, might be reversed.

According to the theory of evolution nature throws off useless members; therefore, in races living in the torrid zone we would expect a total disappearance of the cold-spots as being no longer useful. But if the above experiments are to be relied upon, such is not true in the present case, as we find the highest number of cold-spots on the individuals of those races inhabiting the torrid zone. It may be, however, that what appeared to be an increased number of cold-spots was due to hyperæsthesia of the existing end-organ. Nevertheless I suspect that climate may produce hyperæsthesia or anæsthesia of the temperature nerves, but that there is no marked difference in the number of end-organs in members of different races living under like conditions of temperature.

If it is true that man has a common origin and climate has produced such marvelous changes in color, it certainly would not be illogical to conclude that climate had caused the inhabitant of the torrid zone to be less sensitive to heat and the inhabitant of the frigid zone less sensitive to cold than the inhabitant of the temperate zone.

Following the theory of evolution, and supposing the number of end-organs to have decreased, many generations would be required to show any perceptible difference in the number of end-organs; but supposing anæsthesia of the existing end-organs to have taken place, then but few generations would be required to show a very marked difference. Moreover, we would expect to find this change gradually taking place, at least until the average temperature is no longer a source of discomfort to the inhabitant. I think, however, that we may safely conclude that if there is any difference in the number or sensitiveness of the end-organs in the different races, it is only because of a difference in climatic conditions, and is not due to racial distinctions.

# American Platypezidæ.

BY W. A. SNOW.

Paper II.*

Through the kindness of Professor J. M. Aldrich I have been permitted to examine some additional material in this interesting family. The descriptions of three new species follow, one of which was called *Platypeza velutina* Lw. in Paper I.

**Platypeza abscondita**, n. sp.

Male. Black, opaque. Head, antennæ, palpi and halteres concolorous. Frontal triangle and face somewhat cinereous, bare; cheeks with black pile. Thorax and scutellum in some lights more fuscous black, the latter with several black marginal bristles. Abdomen velvety black, the incisures very narrowly, and the last segment, obscurely cinereous; along the sides with black pile, which is more bristle-like on the last segment. Legs black, the four front tarsi except their tips, brown; first joint of hind tarsi hardly longer than wide, second joint perceptibly wider than long, third joint narrower than the preceding joint and about one and one-half times as long as wide, fourth joint very narrow. Wings hyaline, very slightly cinereous; anal cell sub-equal to the short first basal cell; small crossvein a little more than twice its length from the base of the discal cell, and only once its length distant from the point of divergence of the second and third longitudinal veins; posterior crossvein removed by more than its length from the wing margin; anterior branch of the fourth vein well curved; second posterior cell short, distinctly shorter than the prefurcal section of the fourth vein; the posterior branch of the fourth vein reaches the margin of the wing.

Length 3.3 mm.

One specimen, Craig's Mt., Idaho (Prof. Aldrich).

This species is similar to *velutina* Lw., *anthrax* Lw., *unicolor* n. sp., and *pulla* n. sp.: but differs in the elongate posterior branch of the fourth vein, which reaches the border of the wing. It also differs from each of these species in other alar characters; and from *pulla*, *unicolor* and *anthrax* in its bare face.

* For the first paper see this Quarterly, Vol. III, No. 2, p. 143.

**Platypeza unicolor**, n. sp.

Female. Black, opaque. Head, antennæ, palpi, halteres, and legs concolorous. Face and front slightly and obscurely cinereous; the latter on the sides with short black pile, which, just behind the antennæ, extends nearly across the middle. Face bare except some black pile just above the epistoma; cheeks pilose. Thorax and scutellum fuscous black. The latter with several marginal bristles. Abdomen velvety black, immaculate. Legs altogether black or fuscous black; hind tarsi enlarged, compressed, similar to Figs. 4, 5 in Plate 12 accompanying the former article, but differing in being wholly black, and in having a larger fourth joint. Wings slightly cinereous; small crossvein further removed from the base of the discal cell than in the preceding species but not nearly so far as in *pulla* n. sp., or in other words, the costal cell is one-third longer than the first basal cell; anal cell about twice the length of the second basal cell; the posterior crossvein is near the border of the wing; anterior branch of the fourth vein strongly arcuate, posterior branch short, first posterior cell about equal to the length of the prefurca.

Length 3 mm.

One specimen, Moscow, Idaho (Prof. Aldrich).

This specimen is similar to *anthrax*, *velutina*, *abscondita* and *pulla*. It differs apparently from *anthrax* in that the face is bare except for a small tuft of pile just above the oral opening; it has no rufescent borders to the abdominal segments, the knees are not pallid, the small crossvein is much less remote from the base of the wing, and the second posterior cell is shorter and wider. From *velutina* it may be separated by the wings which are not "purissime hyalinæ," and by the entirely black, not at all lurid legs. Loew does not mention any pile on the face of *velutina*. *Abscondita* is different from the present species in its bare face and in the extreme length of the posterior branch of the fourth vein. *Pulla* is also distinct in its facial and neurational characters.

**Platypeza pulla**, n. sp.

*Platypeza velutina* Snow (non Loew) Kan. Univ. Quar., Vol. III, p. 143.

Certain specimens described in a former paper (l. c.) under the name *velutina* Lw. require a new name. They may be distinguished from Loew's species by the color of the wings which are slightly yellowish cinereous, and by the greater length of the first basal and the second posterior cells. The sides of the face are broadly covered with long thick pile. The present species resembles *anthrax* Lw. in its venation, having extremely long first basal and second

posterior cells. It differs from *anthrax* in its long lateral facial pile and in the lack of a black macula at the base of the last abdominal segment. It is easily separated from *abscondita* and *unicolor*.

**Platypeza ornatipes** Towns.

*Calotarsa ornatipes* Towns. Canadian Entom. XXVII, pp. 50 and 102.

*Platypeza ornatipes* Banks l. c., p. 88; Williston l. c., p. 116; Snow Kans. Univ. Quar., III, p. 143.

On page 102, Vol. XXVII of the Canadian Entomologist, Prof. Townsend has compared his specimen of *ornatipes* with drawings of an insect from Brookings, S. D., sent him by Prof. Aldrich, and concludes that the two are of distinct species. On comparison of Prof. Aldrich's typical specimen, which he has lately sent me, with the type of *ornatipes*, I must confess I can see no specific differences. It should be remembered that Prof. Townsend had only a drawing upon which to base his opinion. The membranous appendage of the third tarsal joint is on the same side of the leg in both specimens; and in both the posterior branch of the fourth longitudinal vein falls short of the border of the wing. In the type specimen the margin of both wings strangely enough was folded over near the tip of the wing which apparently brought the posterior branch of the fourth vein out to the very margin. The other differences mentioned are unimportant.

There now have been three specimens of this species recorded from the widely separated localities Illinois (Prof. Forbes, No. 15,979), Brookings, S. D. (Aldrich, on a window pane), and Ithaca, N. Y. (Nathan Banks).

In Paper I an enumeration was attempted of the species of this family. A recently described species, *Callomyia aurantiaca* Bezzi, taken in the Alps, was omitted. Dr. Bezzi says * that this species is unlike all other known members of the genus in the bright color of the male, previously known males being entirely black. It is interesting to note that in *Callomyia venusta* Snow (l. c.) we have another species in which the males show the bright colors of the females. *Venusta* is easily distinguished from *aurantiaca* by its black thorax and antennæ.

Yet four other species, *C. humeralis* Lw., *P. rectinervis* v.d.Wulp, *P. superba* Kowarz and *P. barbata* Kowarz, all from Europe, should be added to the list, making in all sixty species of this family now known, so far as I can ascertain.

* Wien. Entom. Zeit. XII, 1893, p. 304.

# ERRATA.

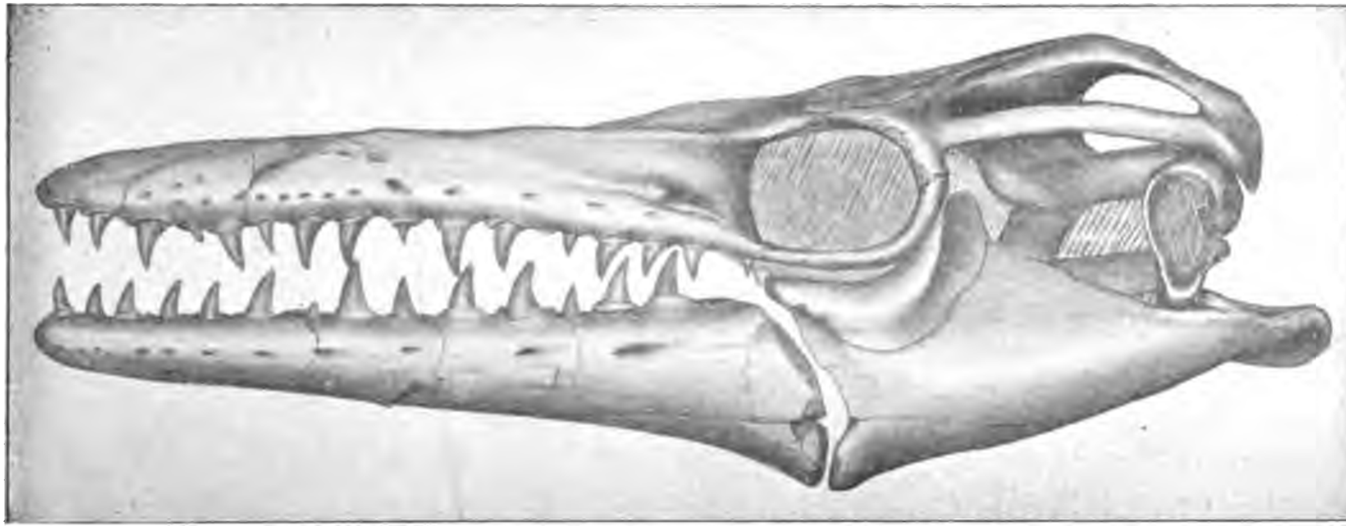
Page 169, 22nd line, read Mosasauridæ Gervais, 1853.

Page 187, insert after "Length 5 mm." the following paragraph: Two specimens, Magdalena Mts., Socorro Co., N. M. (F. H. Snow, Aug.)

Page 187, 8th line, read styliform instead of *stilliform*.

## PLATE XIV.

*Mosasaurus horridus* Williston, side view of skull, a little less than one-fifth natural size (0.17).

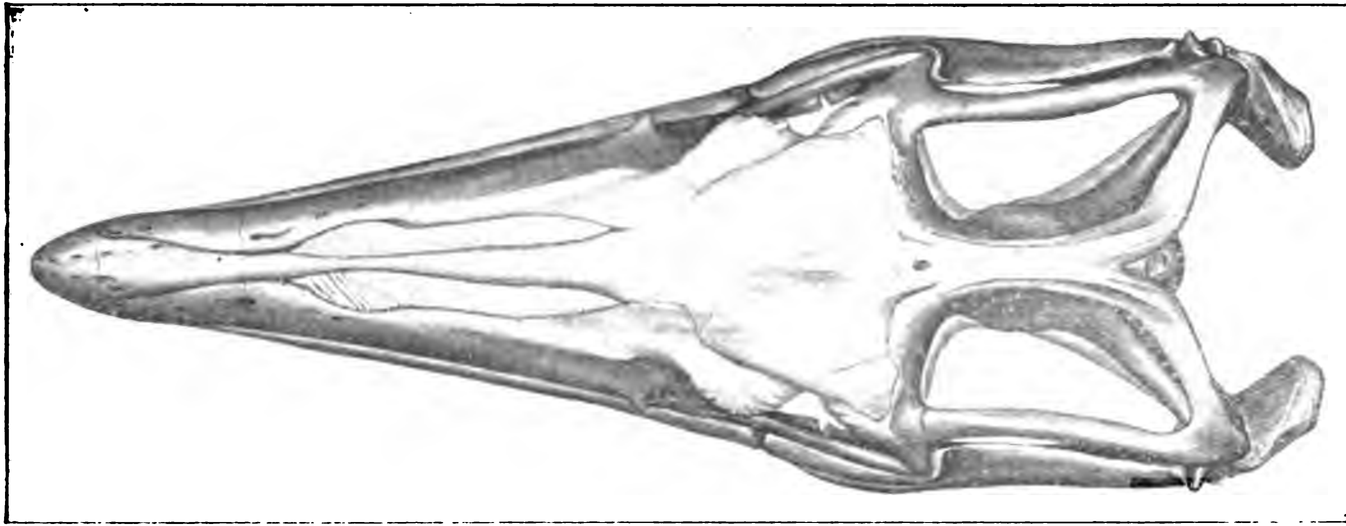


MOSASAURUS HORRIDUS Williston, × 0.17.

S. W. Williston del.

## PLATE XV.

*Mosasaurus horridus* Williston, top view of skull, a little less **than** one-fifth natural size (o. 17).



MOSASAURUS HORRIDUS Williston, ×0.17.

S. W. Williston del.

## PLATE XVI.

Fig. 1. Left front paddle of *Mosasaurus horridus* Williston, one-third natural size. *R*, radius; *U*, ulna; *H*, humerus; *I*, first metacarpal.

Fig. 2. Right quadrate of *Mosasaurus horridus*, inner side, two-thirds natural size.

Fig. 1.

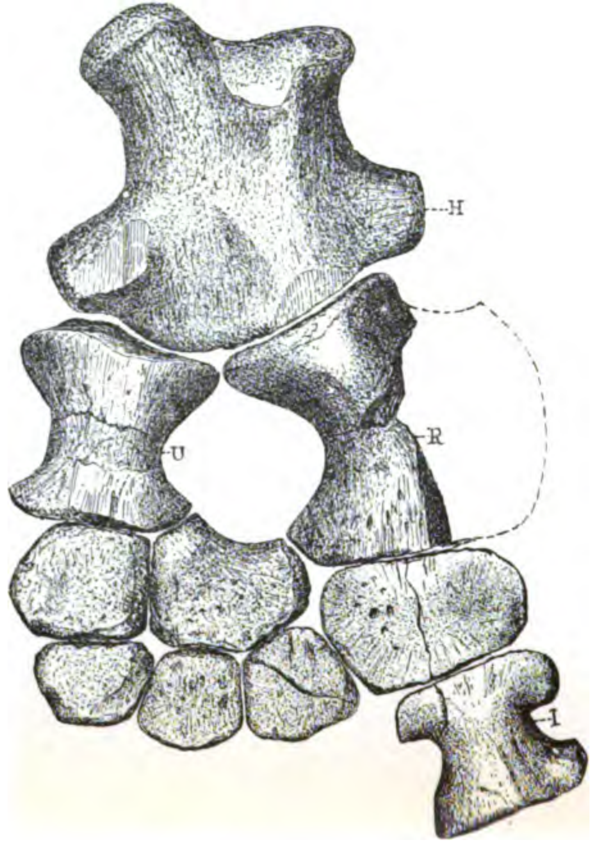
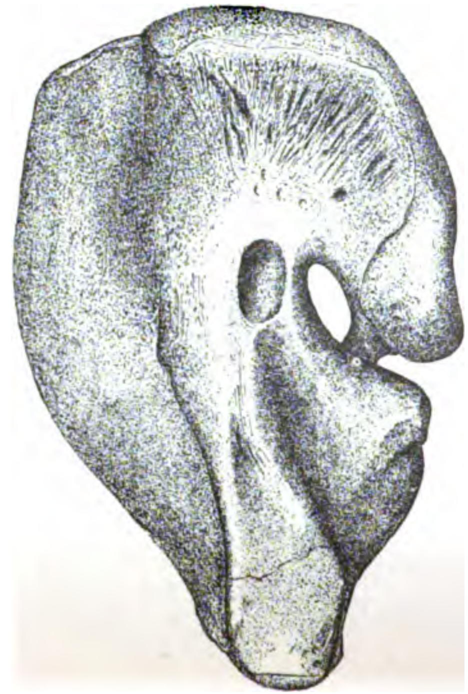



Fig. 2.



S. W. Williston del.

MOSASAURUS HORRIDUS Williston.

## PLATE XVII.

Top view of skull of Mosasaurs.

Fig. 1. *Clidastes velox.*

Fig. 2. *Tylosaurus* sp.

Fig. 3. *Platecarpus* sp.

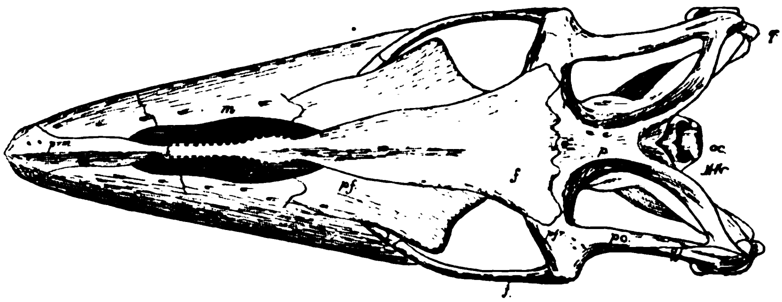



Fig. 1.

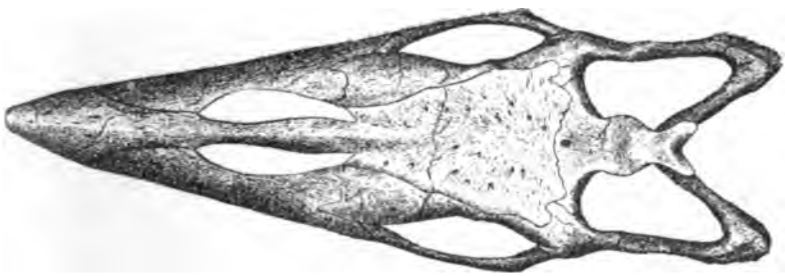


Fig. 2.

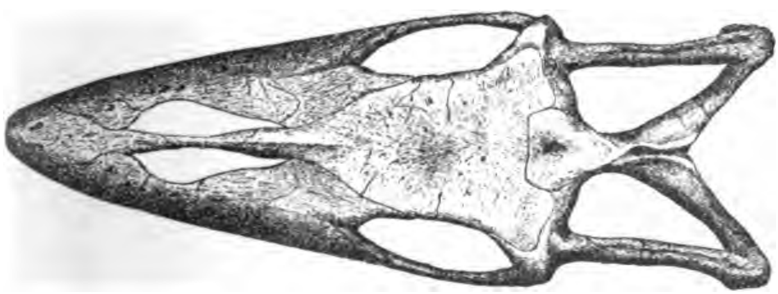
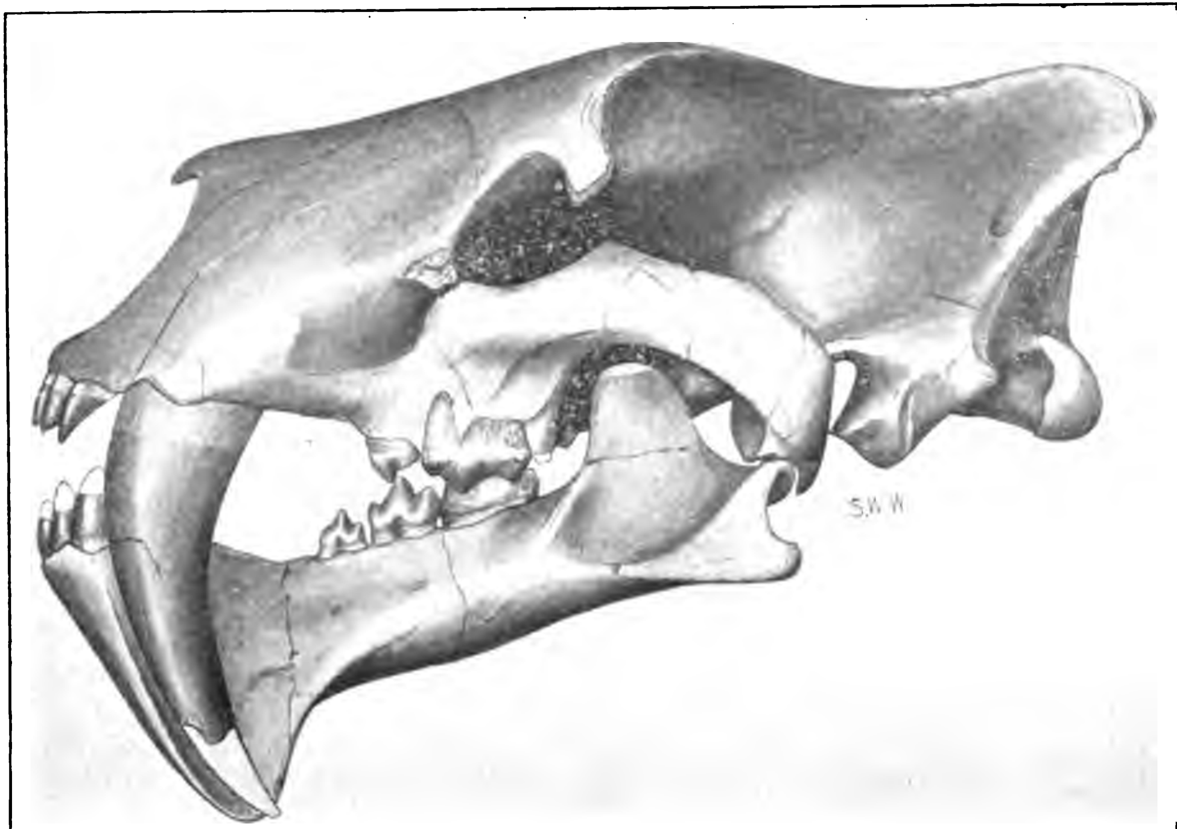


Fig. 3.

M. H. Wellman del.

## PLATE XVIII.

Skull of *Dinotomius atrox* Williston, side view, three-fifths natural size.




S. W. Williston del.

DINOTOMIUS ATROX Williston, × 0.6.

## PLATE XIX.

Fig. 1. *Machærodus* (?) *crassidens* Cragin. Left humerus, posterior view.

Fig. 2. The same, external view.

Fig. 3. *Machærodus* (?) *crassidens* Cragin, left radius, front view.

Fig. 4. *Machærodus* (?) *crassidens* Cragin, third metatarsal, side view.

Fig. 5. *Felis* (?) sp. Right tibia, posterior view.

All the figures are a little more than one-third natural size.

Fig 1.

Fig 5.

Fig. 3.

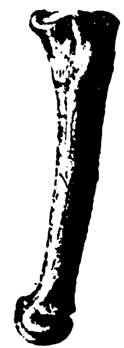


Fig. 4.

Fig. 2.

M. H. Wellman, del.

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# KANSAS UNIVERSITY QUARTERLY.

VOL. III. APRIL, 1895. No. 4


## "Semi-Arid Kansas."

BY S. W. WILLISTON.

(With Map of Kansas.)

The state of Kansas has a superficial area of nearly eighty thousand square miles in the form of a parallelogram four hundred miles long by two hundred broad, stretching from the Missouri river two-thirds of the way to the Rocky Mountains. Its extremes of fertility and barrenness are found in the northeastern and southwestern corners. In the former, with its forty inches of annual rainfall, its varied topography and its deep soil, enriched by the alluvium of the glacial drift, failures of crops are almost unknown, and harvests are bountiful. It is this part of the state which has, preëminently, given to Kansas its reputation for agriculture. In the region at the other extreme, even moderate returns from the husbandman's labors have been the rare exceptions; the land there for a large part of the year lies barren and dead, burnt by the scorching rays of the summer sun, or swept by the bitter winds of winter. Between these two extremes there are all intermediate conditions; imperceptibly the rainfall diminishes from forty to fifteen inches per annum, and the land rises from eight hundred to thirty-five hundred feet in altitude; the bluffs and timbered valleys merge gradually into the high and barren plains, and the rich vegetation into buffalo grass, cactus and yuccas.

While the eastern portion of the state is enjoying a prosperity nowhere excelled, I believe, by any other equal area of agricultural country, the western third has been deserted as utterly unfit for agriculture under present conditions and methods. The reason for this change from fertility to barrenness is not inexplicable, but it is lamentably true that the inevitable results of geographical and geological causes have not been accepted until bitter experience has demonstrated them. In the face of experience, and almost without facts to sustain the theory, it was contended that the rainfall would increase with extended settlements. That the snow-capped Rocky Mountains are

but two or three hundred miles away, condensing all moisture from the western winds; that the vast area of utterly arid region to the southwest could send nothing but siroccos, was not appreciated. The country so fair to look upon in the freshness of spring gave hopes that were almost invariably doomed to disappointment in the Sahara-like dryness of summer. But experience has brought its bitter lesson. Very few now believe that the western third of Kansas can ever become an agricultural country by present methods. Within the past few years there has been an exodus unparalleled elsewhere, save in the similar regions of Nebraska. Houses and claims by the thousand have been abandoned, and whole villages, which but a few years ago were bustling with activity, stand almost deserted and uninhabited.

Unfortunately, in learning this lesson, there has been incredible suffering, both on the part of the actual settlers and on the part of many thousand others whose means have been wasted and who know and remember Kansas only to curse it. Hundreds of thousands of dollars have been sunk in this gigantic and almost useless experiment. And much of the blame lies at the doors of those corporations and those men who knew better, but who used the opportunity to enrich themselves at the expense of the ignorant.

With the western boom that gathered force in 1886 and 1887 settlers flocked into western Kansas, the most in good faith, and located hundreds of thousands of acres of the high, dry uplands. Rude houses were made, towns were built, often on an extravagant scale, costly public buildings were erected, bonds were voted and railroads constructed in doubtful or useless places, and nearly all with the promise to pay. Real estate agents reaped a bountiful harvest. Money was poured in by credulous eastern lenders, and agents were bribed to be dishonest or imprudent by receiving a commission on the money they loaned. In ignorance or cupidity they vied with each other in loaning the most money. Land rapidly obtained a fictitious value and nearly every place was mortgaged, often for many times what it is now worth. Numerous cases have come within the writer's knowledge where land has been deliberately abandoned after getting a mortgage loan upon it. He has also known instances where the gift of land has been refused which a few years ago could have been mortgaged for from three to five dollars an acre. It is the mortgagees, usually persons of limited means, who now own the larger part of much of this western land. They are carrying the almost useless burden of taxation upon these unproductive lands, in the hope that something will be retrieved from utter loss. Only a few years ago a costly, extravagant court house was built in Clark county from bonds voted by men nearly all of whom owned no

land or property. They boasted that they would let the "capitalists" who owned the land pay for it. It is not an exceptional case. But the dishonest have not been the rule; most of the people have been sincerely honest in their intentions, and have had courage where courage seemed useless. However, there is no question but that all of Kansas has suffered in reputation for the western part.

The lesson is now learned, the bubble has burst, and because the real truth concerning this country is now known the prospects of western Kansas are beginning to brighten. The exodus began some years ago. It has been stayed now and then, but has been greatly accelerated the past year. In a large part of western Kansas there was an utter drouth from August, 1893, to the middle of May, 1894, and even the most hopeful at last lost hope. A very frail straw floated on the current of withered expectation in the shape of "rainmaking." Many sensible men secretly hoped that there was something in the theory that a little hydrogen gas liberated into the heavens would bring unlimited quantities of water. By a singular irony of fate, however, the very home of the rain-makers has been the driest spot of all Kansas the past year or two. This last resting place for hope is now gone. The cry now is "Irrigation or emigration."

In all prudence, the subject of irrigation is one demanding consideration. There are twenty or more thousand square miles of arable land, with a soil equal to any in the state, capable, as has been abundantly proven, of producing as good crops as any in the state, that are well worthy of a moderate amount of time and money to demonstrate their possibilities and impossibilities. For twenty years the writer has been familiar with the meteorological and geological conditions of "semi-arid" Kansas, as he has always called it, and as it is now frankly admitted to be, and he has never lost faith that some day the region would offer resources for a prosperous, though limited, population.

Just where are the limits of profitable non-irrigated land, it is now impossible to say. Even in the best parts of the state there are seasons and times when irrigation would be desirable or even profitable. As we go further west, the average annual productiveness decreases. Thirty-seven years ago, when the writer first knew Kansas, Manhattan or Junction City was thought to be about on the border of the "Great Desert," and the school maps were not yet quite done locating this desert a little further west. At Salina there are few years when irrigation would not be advantageous. In the extreme western part there is not one year in six when irrigation is not required in the production of crops. The need of irrigation is much more extended than its profitableness. That can only be determined by its cost in comparison with the average annual increased

productiveness therefrom, and this will vary with cost of land and the market value of the produce. This must of course be borne in mind in answering the question whether irrigation will pay in *any* part of the state. Twenty years ago the cheapest irrigation did not pay for the general market, because land that did not need irrigation was too cheap elsewhere. But there is no more good land to be had for the asking, or even for a moderate price. The money, then, that must now be put into expensive land may be profitably put into cheap land and the residue used in irrigation. That is practically the condition that much of western Kansas has nearly or quite reached.

The fall of snow in this "semi-arid" region is usually light, though sometimes excessive. Because of the rolling surface and the almost incessant winds, what snow falls is rarely evenly distributed, and is thus of little service in moistening the ground. The season, from the higher altitude, is a week or more later than in the eastern part of the state, and killing frosts occur later than with us. April and May are usually wet months, the rainfall in the majority of seasons being sufficient to germinate and nourish crops. Unfortunately, however, the dryness of the winter is often such that wheat is killed before this time. In June, while the rainfall is not abundant, it is generally sufficient up to the middle of the month. Beginning with the latter part of June and continuing into September, few or no rains are the general rule, together with continued hot, dry winds from the southwest, which parch and burn almost everything that is not supplied with moisture. In September there is usually rain again, and vegetation becomes green. In only one of the six summers I have spent on the plains have I not known the prairie grass sufficiently dry to burn in the early part of July. During July and August there are frequent attempts at rain, but the clouds seldom shed more than a few drops of moisture to the ground. So dry is the atmosphere that a slight shower will lower the temperature remarkably. I have known the thermometer in a single day in July to fall from 104° to 42°. The maximum temperature for this season is from 94° to 104°, but sometimes getting up to 108° or even higher. As a result of this excessive heat and dryness, storms are apt to be violent, and hailstorms are more frequent and more to be dreaded than in eastern Kansas. This is to be taken into account in the problem of water storage; the fifteen or eighteen inches of annual rainfall is of much less service than it would be if so much of the water did not immediately run away.

The question of irrigation in western Kansas resolves itself into the solution of three principal problems, viz: the utilization of surface water by empounding and distribution; the utilization of the water of streams by ditches; and the use of ground-water by means of the pump.

The utilization of surface water in an economical way depends upon a number of yet unsolved problems—the matter is by no means so simple as some believe. The land is of a gently undulating character, and no reservoirs can be constructed, save at great expense, which will not present so great a surface to the atmosphere that the intense evaporation of the summer months will not dry them up. Professor Hicks, of the University of Nebraska, has attempted to show that water-storage on the plains is practically impossible. While not wholly agreeing with him, it is apparent that the utility of such is by no means what has been claimed for it.

The utilization of river water can be of but comparatively limited extent. There is but one stream in the state—the Arkansas—which receives its water from outside the arid regions. In this stream the visible supply is limited, in fact is already practically exhausted. But the valley is from ten to twenty miles broad, with an underflow probably nearly everywhere forty to sixty feet deep. The use of this underground flow is, of course, both possible and economical. It is thus not at all improbable that nearly the entire extent of this valley will be put under profitable irrigation at no late day, even as a considerable portion has already been.

But the whole region thus capable of irrigation is very small in proportion to the vast area of upland.

The third and last problem, and the one upon which the future of western Kansas practically depends, is the so-called underflow of the uplands. Although the explanation of this underflow or sheet-water is simple enough, I doubt if the most of those who use the terms understand just what they mean. For this understanding, a knowledge of the geological features of western Kansas is necessary. But the facts are simple: it does not need the acumen of an expert geologist to understand them. Running across the state from Jewell county on the north, through Ellsworth county and into Colorado near Coolidge, there is a strip of exposure of variable width known as the Colorado Cretaceous. The rocks are invariably soft limestones, lime shales, or pure homogeneous chalk, with an estimated thickness of from five to eight hundred feet. The deposits are marine and are practically impervious to water. After their elevation, the whole country was subjected to erosion through long periods of geological time. During this time the surface had practically reached the present configuration and the Arkansas, Smoky Hill and other valleys had been scooped out. At the close, the land of the plains was again depressed into a series of extensive fresh-water lakes, extending from Dakota to Texas. The deposits laid down in these basins were composed of the debris from the Rocky Mountain sandstones and

granites, somewhat mixed with the chalk beneath. Since the time of the drying up of these lakes the land has been again elevated and the sandstones and sand deposits eroded down to the impervious chalk and limestones beneath them in most of the valleys, leaving on the uplands an immense area of remarkably flat lands with a gentle inclination towards the east. The dip of the chalk and limestones is markedly toward the northeast, but the old erosion is gently toward the east, nearly parallel with the surface of the land above it. Lying on this fairly uniform surface are the Tertiary sandstones of nearly uniform thickness, from one to two hundred feet. Now, if I have made my meaning clear, it will be seen that the water falling upon the surface and percolating to the bottom of the pervious sandstones and meeting the inclined surface of impervious chalk, will flow off gradually to the east through the sand. It is this layer of water, of unknown quantity, which has received the name of sheet-water or underflow. Where erosion in the valleys and along the eastern border has exposed the line of contact between the sandstone and limestone, water flows out, often in clear springs, usually under the later alluvium down into the valley. It thus happens that wherever in western Kansas the valleys cut down through the sandstone there are pools of water which never dry up, and even flowing streams. In earlier days these pools were the favorite homes of many beavers and of countless fishes. These streams or series of deep but narrow ponds, filled with vegetation, are often ten, twenty or more miles in length, as in the Saline river in Trego county, or the Smoky Hill at Wallace. After a while, however, the water is absorbed through the adjacent soil and the valleys are perpetually dry, or nearly so, save after rains.

Simple as all this may be to one who has observed the cause, it has been rarely understood in this part of the state, and I have seen innumerable attempts to get water in the utterly barren chalk. There is a considerable area of this waterless rock bordering the Tertiary, as shown in the map, where irrigation from underground water is simply out of the question. The chief need of a geological survey for irrigational purposes is to fix the limits of the water-bearing area more closely. As given in the map, it is wholly derived from my own observations, and can make no pretentions to close accuracy.

In the comparatively limited area where this underflow sinks into the alluvium, even good crops can often be raised wholly without irrigation. In the dryest seasons I have seen excellent crops of wheat on Butte Creek, near the western line of the state, that would have done credit to eastern Kansas. And there is no doubt but that even more of this underflow could be utilized by such crops as alfalfa, which seek their moisture at considerable depths.

Still, the utilization of the underflow where it comes near the surface is a small part of the problem of irrigation in western Kansas. The main problem, after all, is, how can the water underlying the uplands be brought to the surface economically, and the next most important problem is, how much water is there in this underflow? Here we have almost no facts to go upon, except those of rainfall, and the area of pervious rocks forming the water-shed. It is believed by many that this water comes from the Rocky Mountains, a belief from which I totally dissent. It is known that in northeastern Colorado there are an immense number of what are called sink-holes. I have not seen these, but I have seen similar ones in Kansas, the valley of the White Woman in Scott and Greeley counties for instance, a long valley draining hundreds of square miles, debouches into a large sink near Scott City. This sink is of large area, though shallow. After rains it forms a lake, but the water soon sinks into the ground and leaves the bottom dry. In traveling from the Smoky Hill river to Scott City, a distance of twenty miles, a good barometer did not show over ten feet difference in altitude in the whole distance. Everywhere after rains there are pools and ponds of water over these flat plains, whose declivity is about five feet per mile to the east. There is need here of investigations by a competent hydrographic engineer, based upon the features of streams, soil, vegetation, rainfall and evaporation. As I have already said, the geology of the question is so simple that it falls far into the background. Can the water be economically raised to the surface? Is it sufficiently abundant? These are the questions that only time and money can solve. During the past August I saw garden crops in small patches growing with luxuriousness in the highest and driest region of Kansas, irrigated by wells. At present it is believed that a plant costing two hundred dollars will be sufficient to irrigate an acre of land. Is it economy to invest this much in agricultural land in Kansas? How much can this cost be reduced by improved methods and coöperation? These are questions to be solved, and in their solution state or national aid may be justly demanded.

After all this has been satisfactorily demonstrated, there remains much yet for the agriculturist to learn in the methods of application and the treatment of crops.

As regards artesian wells there is a geologic possibility, but so little do I think that they will enter into the problems of irrigation in western Kansas that I do not deem it worth while to consider them.

In the accompanying geological map of Kansas, the boundary of the formations above the Carboniferous have been almost wh derived from my own observations made during the past tw years, and in many cases cannot lay claim to close accuracy.

The Tertiary area indicated is for the greater part the area of water-bearing rocks. The lowermost portions of these beds are, i probability, the Nebraska beds of the Loup Fork Miocene. A them occur the Palo Duro and Equus beds of the Pliocene Pleistocene. The rocks of the Nebraska beds are usually c sands and sandstones. Above them the deposits are mostly s and sandy marls. Altogether the beds are from one hundred to hundred and fifty feet in thickness.

The Ft. Pierre beds of the Montana Cretaceous are in K wholly composed of dark blue shales with argillaceous concret and altogether do not exceed one hundred feet in thickness.

The Niobrara beds of the Colorado Cretaceous are wholly posed of blue, white and buff chalk, and measure about four hun and fifty feet in thickness.

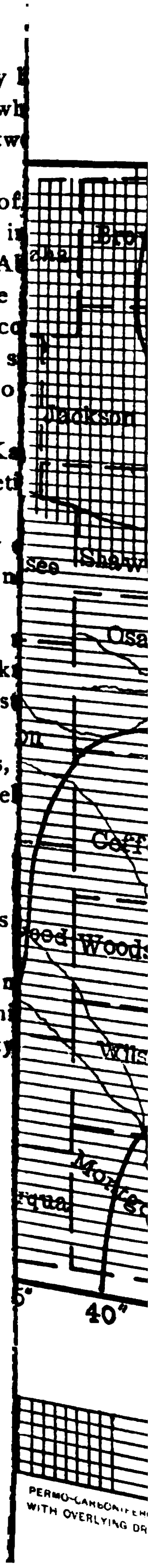
The Benton beds of the Colorado Cretaceous are formed of solid, stratified chalk or soft limestone, about eighty feet in thick with beds of dark blue shale and strata of solid yellow limes making altogether about four hundred feet.

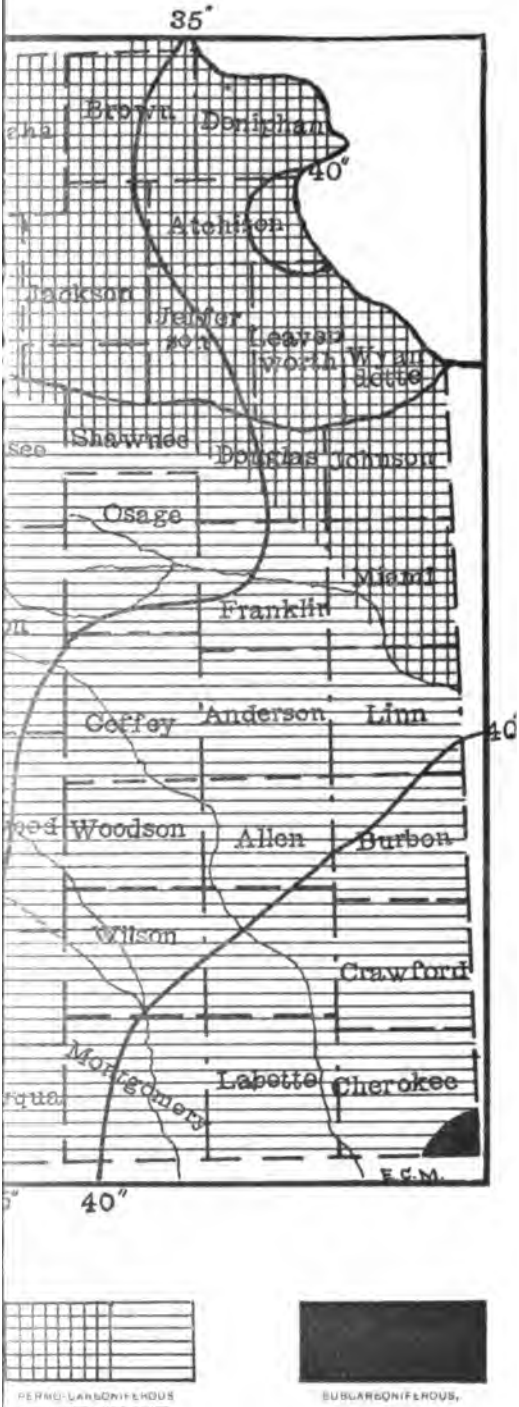
The Dakota Cretaceous deposits are nearly wholly sandstones, ally of a dark red color, though sometimes softer and more ye They are about three hundred feet in thickness.

The Comanche Cretaceous is composed of sandstone and blue shales measuring about one hundred feet.

The Triassic beds are composed of red sands and sandstones layers of gypsum.

The Carboniferous has beds of clay shales and limestones in upper part and limestones, shales, sandstones and coal in the mi and lower portions. Their whole thickness is about twenty hundred feet.




35'
Brown
Doniphan
40"
Atchison
Jackson
Jeffer son
Leaven worth
Wyan dotte
Shawnee
Douglas
Johnson
Osage
Miami
Franklin
Coffey
Anderson
Linn
Woodson
Allen
Burbon
Wilson
Crawford
Montgomery
Labette
Cherokee
E.C.M.
40"
PERMO-CARBONIFEROUS WITH OVERLYING DRIFT.
SUBCARBONIFEROUS.

# Collection and Storage of Water in Kansas.

BY E. C. MURPHY.

(With Map of Kansas).

This problem is one of the greatest importance to the people of Kansas. We have such a large amount of land which is practically useless without water, and which is exceedingly productive when irrigated. We also have a large amount of water running to waste in our streams, which not only is doing us no good, but doing much harm in the way of destruction of property along the banks.

Some idea of the value of water for irrigating purposes may be gotten from the prices paid for it in southern California. At Los Angeles a flow of from 2 to 4 cub. ft. sec. for 24 hours sells for $2.00; at Orange a "head" equal to about 2 cub. ft. sec. for 24 hours sells for $2.50; at Riverside a flow of 1 cub. ft. sec. for 24 hours sells for $3.00. Mr. J. P. Flynn, C. E., has estimated that a flow of 1 cub. ft. sec. under favorable circumstances for all time is worth in southern California $40,000.

This is a very complex problem; there are so many factors on which its solution depends. The principal ones are: physical features of the surface, rainfall, evaporation and percolation.

There are three possible sources of water supply in Kansas—surface water flowing in the streams; storm water, which may be stored in draws; and underground water.

The rivers of Kansas with one exception, the Arkansas, are rivers of the plains; their source of supply is the rain falling on the plains. They have a large and sudden flood flow, and a very small flow during dry spells. Some of them have no visible water in them for weeks at a time. They rise quickly during a heavy rain and subside rapidly after the storm is over. They flow over and through formations which are readily eroded, and hence carry a large amount of sediment. The beds of some of the larger ones being sandy have a considerable underflow; this is especially true of the Arkansas and Cimmaron.

The Arkansas, being a mountain stream, differs from the other Kansas rivers in having a flood flow in May, due to the melting of mountain snow. This flood flow does not last long in Kansas, as so much of the water is used by the people of Colorado for irrigating

purposes. During the remainder of the year it resembles the other plains rivers.

The only published measurements that I have seen of the flow of Kansas streams are those for the Republican, Smoky Hill, Kaw, Solomon and Saline, made by Prof. Hay and published in the U. S. Irrigation Report in 1893. They are as follows:

| RIVER. | PLACE. | DATE. | VOLUME, CUB. FT. SEC. |
|---|---|---|---|
| Kaw | Fort Riley | June 18, '91 | 6961 |
| Republican | Scandia | June 10, '91 | 1534 |
| Republican | Junction City | June 15, '91 | 2045 |
| Smoky Hill | Ellsworth | June 8, '91 | 360 |
| Smoky Hill | s. w. Junction City | June 15, '91 | 961 |
| Solomon | Beloit | June 19, '91 | 270 |
| Saline | Lincoln | June 8, '91 | 125 |

These seven single measurements are good as far as they go, but they are too few to be of any value in making estimates. The Arkansas, Cimarron and other streams might be included in this table since their visible flow is nothing at times. Measurements of flow, to be of much value in computing water supply and storage, should be made daily or oftener for a period of years.

The mean annual rainfall in Kansas varies from about 45 inches in the southeastern part to less than 15 inches in the southwestern part. On the accompanying map we have drawn the curves of mean annual rainfall for each 5 inches variation. They are drawn from the rainfall records of thirty-four places in Kansas published in the biennial reports of the Board of Agriculture. The length of these records varies from two years in the western part of the state to thirty-three in the eastern part. The western curves are based on so little data that they may be changed a good deal by future data. Another fact in regard to these records must be kept in mind; some of them are older than others, and their mean may be considerably above or below the mean of a later period.

These curves extend approximately northeast and southwest except in the northwestern part of the state where they bend to the northwest. They are considerably nearer together in the eastern half of the state than in the western half.

We are concerned with the maximum and minimum rainfall as well as the mean. The future storage basins of Kansas will probably not be large enough to store a supply of water for more than one year, so that the water from the minimum rainfall is all that the farmer is sure of. The maximum should be known in order to properly proportion the spillway and thus insure the permanence of the works.

The rainfall varies a good deal in Kansas from year to year. In Table I we give the maximum, minimum and mean annual rainfall, and length and time of record in twenty-one places in Kansas.

TABLE I.

| PLACE. | Years of Observation. | Maximum Annual Rainfall. | Minimum Annual Rainfall. | Mean Annual Rainfall. | Years of Record. |
|---|---|---|---|---|---|
| University of Kansas, Lawrence | 25 | 44.18 | 24.25 | 35.65 | 1868–92 |
| Agricultural College, Manhattan | 33 | 45.86 | 15.17 | 30.81 | 1858–90 |
| Leavenworth City | 21 | 52.06 | 22.45 | 37.98 | 1872–92 |
| Dodge City | 18 | 33.55 | 10.69 | 20.87 | 1875–92 |
| Independence | 20 | 55.04 | 26.56 | 43.01 | 1873–92 |
| Washburn College | 14 | 43.28 | 23.23 | 33.93 | 1872–92 |
| Wellington | 12 | 40.49 | 19.70 | 31 88 | 1879–90 |
| Fort Scott | 10 | 62.60 | 29.25 | 42.13 | 1843–52 |
| Fort Larned | 11 | ..... | ..... | 20.60 | 1864–77 |
| Fort Wallace | 5 | 16.35 | 6.57 | 13.21 | 1870–74 |
| Fort Hay | 7 | ..... | ..... | 22.77 | 1868–74 |
| Eureka Ranch | 10 | ..... | ..... | 18.78 | 1881–90 |
| Concordia | 5 | 34.47 | 17.61 | 27.38 | 1888–92 |
| Allison | 5 | 29.87 | 19.89 | 24.35 | 1884–88 |
| Salina | 6 | 30.60 | 20 80 | 26.93 | 1883–88 |
| Sedan | 5 | 44.53 | 23.22 | 35.47 | 1888–92 |
| Toronto | 5 | 48.68 | 28.86 | 36.31 | 1888–92 |
| Cawker City | 5 | 30.50 | 12.86 | 20.90 | 1888–92 |
| Atchison | 7 | ..... | ..... | 43.07 | 1867–73 |
| Cunningham | 7 | 31.65 | 20.29 | 25.72 | 1884–90 |
| Halstead | 6 | 32.40 | 21.40 | 26.26 | 1885–90 |

From this table it is seen that the maximum annual rainfall is more than three times the minimum at some of these places—Dodge City for example.

TABLE II.

| PLACE. | Monthly Rainfall. | | | | | | | | | | | | | Extent of Record. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan. | Feb. | Mar. | April | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Mean. | |
| Lawrence | 1.26 | 1.28 | 2.20 | 3.17 | 4 05 | 4 94 | 4.26 | 3.60 | 3.60 | 2.89 | 1.87 | 1.61 | 34.66 | 1868–88 |
| Independence | 1.52 | 2.18 | 2.08 | 3 68 | 4.23 | 5.75 | 4.03 | 3 23 | 3.72 | 2.98 | 1.99 | 2.97 | 44.25 | 1873–88 |
| Manhattan | 0.79 | 1.16 | 1.46 | 2.80 | 4.06 | 4.56 | 1 67 | 3.51 | 3.31 | 2.45 | 1.41 | 0.90 | 30.89 | 1858–87 |
| Salina | 0.82 | 0.82 | 0 95 | 3.03 | 3.33 | 4.33 | 4.50 | 3.63 | 1.80 | 2 52 | 0.43 | 0.77 | 26.93 | 1883–88 |
| Wellington | 0.71 | 1.12 | 1.24 | 3.28 | 4.89 | 4.41 | 3.99 | 2 91 | 3.80 | 3.28 | 0.99 | 1.05 | 32.05 | 1879–88 |
| Allison | 1.26 | 0.86 | 1.31 | 3.11 | 3.14 | 2.93 | 4.18 | 2.65 | 1.76 | 1.17 | 0.43 | 0.76 | 24 35 | 1884–88 |
| Dodge City | 0 37 | 0.55 | 0.82 | 1 58 | 3.89 | 3.37 | 3 37 | 3.14 | 1.23 | 1.24 | 0.57 | 0.76 | 20 91 | 1875–88 |
| Fort Wallace | 0.09 | 0.20 | 0.07 | 1.75 | 2.74 | 1.03 | 2.82 | 1.20 | 1.23 | 2.38 | 0 46 | 0.10 | 13.21 | 1870–74 |

Table II gives the mean monthly rainfall at eight places in the state. It shows how the rain is distributed during the year. It is least during the winter and increases until June when it is four or more times greater than in January. The variation in the monthly rain for any month from year to year is quite great; for example Chancellor Snow's record shows that in August, 1882, the rainfall was 0.09 inches, while in August, 1888, it was 9.09 inches, the latter being 100 times the former.

The places in Table II are chosen so as to show the variation in the monthly rainfall over the state. The first two places are in the eastern part, the next three in the east central, the two following in the west central and the last in the extreme western part. It will be seen that as the mean annual rainfall decreases, the proportion of it falling during the winter decreases.

Not only the amount of rainfall but the part of it flowing into the streams, or the run-off, must be known before the quantity of water a given area will furnish can be computed. This run-off depends on the rainfall area drained, kind and condition of soil, and inclination of surface. It is greatest where the surface is steep and rocky and the rain falls very rapidly. Mr. J. T. Fanning, C. E., estimates the run-off from a flat, cultivated prairie country to be from 45 to 60 per cent of the mean annual rainfall. In some parts of Kansas the soil is very loose and sandy; in other parts the surface is covered with a tough, buffalo grass sod. From the former the surface run-off is very little, not more than 25 per cent; from the latter it is probably at least 60 per cent.

Evaporation and percolation as here considered are the losses of water from the reservoir, i. e., after collection. The former is the part which passes off into the air; the latter, that which passes off into the ground through the bottom and sides of the reservoir. The former takes place at all times, though most rapidly during the hot, dry summer months; the latter loss is greater when the reservoir is new, and grows less and less as the fine materials in the water fill up the pores of the soil. Evaporation takes place most rapidly when the air is very dry, the water warm and a brisk wind is blowing. These are the conditions existing in western Kansas, and consequently the evaporation is quite great.

The only recorded measurements of evaporation in Kansas that the writer has seen are those made by Mr. T. Russell, of the United States signal service at Dodge City. They were made with the Piche evaporometer and for one year only. He also measured the evaporation at several other places in the west.

Table III gives the monthly evaporation at eleven places as found by Mr. Russell; also the mean annual rainfall from Ex. Doc. 91, 50th Congress, first session, and the altitudes from Henry Gannett's dictionary of altitudes.

It seems to us that the evaporation at Dodge City as given in this table is too small. Compare for example the evaporation of Dodge City with that of Salt Lake City; the latter is 1800 feet higher and four degrees farther north than the former; the rainfall is about the same for both. We would, therefore, expect the evaporation at Dodge

City to be a considerable amount greater than that of Salt Lake City. As given in this table the evaporation of Salt Lake is 74.4 inches, and that of Dodge City only 54.6 inches.

The percolation loss from a reservoir is difficult to measure. It is usually considered in connection with evaporation. As these two

TABLE III.

| PLACE. | Monthly Evaporation. | | | | | | | | | | | | Year. | Mean Annual Rainfall. | Elevation. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan. '88. | Feb. '88. | Mar. '88. | April, '88. | May, '88 | June, '88. | July, '87. | Aug. '87. | Sept '87. | Oct. '88. | Nov. '88. | Dec '87. | | | |
| Dodge City, Kansas | 1.4 | 2.4 | 2.8 | 4.1 | 4.6 | 7.4 | 8.3 | 6.6 | 5.5 | 5.2 | 4.2 | 2.1 | 54.6 | 20.87 | 2475 |
| Cheyenne, Wyoming | 3.3 | 5.7 | 4.0 | 8.2 | 5.2 | 10.4 | 8.0 | 7.7 | 8.6 | 5.8 | 6.1 | 3.5 | 76.5 | 11.32 | 6069 |
| Colorado Springs, Colo. | 3.0 | 3.3 | 4.1 | 6.7 | 5.6 | 4.3 | 6.7 | 7.2 | 6.8 | 4.6 | 4.2 | 2.9 | 59.4 | 15.79 | 6010 |
| Fort Davis Texas | 5.4 | 5.7 | 6.7 | 8.5 | 11.0 | 12.0 | 11.4 | 9.0 | 5.9 | 5.2 | 5.7 | 4.9 | 96.4 | 17.71 | 4700 |
| Santa Fe, New Mexico | 3.0 | 3.4 | 4.2 | 6.8 | 8.8 | 12.9 | 9.2 | 9.8 | 6.6 | 6.7 | 5.7 | 2.7 | 79.8 | 14.81 | 7047 |
| Yuma, Arizona | 4.4 | 5.2 | 6.6 | 9.6 | 9.6 | 12.6 | 11.0 | 10.2 | 8.2 | 8.2 | 5.5 | 4.6 | 95.7 | 2.81 | 142 |
| Winnemucca, Nevada | 0.9 | 2.8 | 6.2 | 9.1 | 9.3 | 10.1 | 11.5 | 12.0 | 9.9 | 6.6 | 3.7 | 1.8 | 83.9 | 7.93 | 4332 |
| Salt Lake City, Utah | 1.8 | 2.7 | 3.6 | 7.2 | 6.9 | 8.9 | 9.2 | 10.7 | 9.6 | 6.5 | 5.0 | 2.3 | 74.4 | 21.20 | 4354 |
| Boise City, Idaho | 1.6 | 2.5 | 3.8 | 6.1 | 6.5 | 6.6 | 10.0 | 9.2 | 7.4 | 5.2 | 3.2 | 1.8 | 63.9 | 14.74 | 2768 |
| Sacramento, Cal. | 1.8 | 3.1 | 3.7 | 4.3 | 4.2 | 5.6 | 5.9 | 5.6 | 6.5 | 7.3 | 3.9 | 2.4 | 54.3 | 19.69 | 82 |
| Fresno, Cal | 1.8 | 2.8 | 3.0 | 5.6 | 6.0 | 7.0 | 9.1 | 10.2 | 7.6 | 6.7 | 3.8 | 2.2 | 65.8 | 8.79 | 314 |
| Cambridge, Mass. | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 56.0 | | |
| Syracuse, N. Y. | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 50.2 | ... | 403 |
| Cotton River, N. Y. | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 24.2 | | |

constitute the total loss, it can be easily found from the differences in depth of the reservoir at any point at two given times.

The percolation varies from almost nothing in a well constructed reservoir to a large amount in the case of a natural reservoir with sandy or gravelly bottom. Not only alluvium, but rocks also, allow water to pass through them with more or less freedom. The amount which passes varies with the porosity and pressure. Loose sand will absorb from 30 to 35 per cent of its volume, a gravelly sand from 20 to 25 per cent, marl from 10 to 20 per cent, clay from 10 to 15 per cent, chalk, sandstone and limestone from 10 to 20 per cent. A formation which is nearly impervious at a low pressure may allow much water to pass under a head of 30 or more feet.

Not only does the porosity of soil vary a good deal but the variation is often quite sudden. A clay soil in one place will hold the water quite well; in another place, only a short distance from the first, it may be sandy and allow the water to pass through it almost as through a fine sieve. It is impossible to predict from the porosity of the soil in one valley what that in another valley is, even though they be but a short distance apart. A careful examination, not only of the surface formation, but also of the underlying ones is necessary in order to determine approximately what the percolation from a reservoir in a given valley will be.

Some idea of the percolation through western Kansas soil may be gotten from that from the Perry ditch in Clark county. This ditch

is $8\frac{1}{2}$ miles long, 15 feet wide at top, 9 feet wide at bottom, 2 feet deep, and has a grade of $2\frac{1}{4}$ feet to the mile. There are places along it where the uphill bank was not constructed, and the ditch widened out into shallow ponds, the area of which was estimated to be three acres with an average depth of 6 inches. When water was let into it for the first time, it was fourteen days from the time the gates were opened until the water reached the end of the ditch. The cross section of the stream being 24 square feet, and the mean velocity 1.925 ft. sec., 55,884,000 cubic feet of water entered the fourteen days, 1,177,000 cubic feet were in the ditch and ponds at the end of the time, hence 54,706,000 cubic feet, or more than 50 ditchfulls were lost while the water went a distance of $8\frac{1}{2}$ miles. Now, after being used eight years, if the water is shut out for a short time and again admitted into the ditch, it will flow the length of it in seven and one-half hours.

The valleys of Kansas are not favorable for the storage of large quantities of water. They are broad and shallow as a rule, decreasing in width and depth from the east toward the west. Their breadth necessitates the construction of long and expensive dams and the flooding of large areas, and this broad water surface increases greatly the evaporation and the percolation losses. The soil in the larger valleys is sandy, allowing water to pass through readily and making a foundation difficult.

The sub-surface of Kansas seems at first sight to be equally unfavorable to the storage of water. The surface slopes to the east, while the sub-surface layers or strata slope or dip north and east. The rivers flow over the edges of the upturned beds, and would lose part of their water into them if other conditions were favorable. The Smoky Hill river, for example, flows over the ends of the Tertiary, Cretaceous, Permian and Upper Carboniferous formations. All of these absorb some water. The Dakota Cretaceous and Lower Tertiary absorb more than the others. But the condition of affairs is not so bad as at first sight. The upper Cretaceous or Niobrara, although it absorbs considerable water, will not allow much to pass through it; and although its dip is north and east, its upper surface is eroded and slopes a little to the east and south; so that the Lower Tertiary, the most important water-bearing stratum in Kansas, dips east and south, bringing water into the rivers instead of taking it from them. Most of the streams in western Kansas have no permanent water in them until they have cut through the Tertiary grit as it is called.

Millions of cubic feet of water are annually going to waste in the Arkansas River. Can this water not be stored on Kansas soil? Not in the ordinary way by constructing a dam across the valley. Is

there no other way of storing it? There are nine canals in western Kansas taking water from this river. Their combined capacity is about 2200 cubic feet per second, equaling 4400 acre feet per twenty-four hours, or 7 square mile feet per twenty-four hours; that is, the water which these nine canals will take from the river each twenty-four hours, when working at full capacity, will fill a reservoir one mile square to a depth of 7 feet. This is a good sized reservoir and these canals will fill it once in twenty-four hours.

One objection to these canals is that they are too long, the reservoirs are too far from the river, and there is too great a loss of water between river and reservoir. Another fault is that the dams are not strong enough to divert a large amount of water into the canals; in fact, they are swept away at each freshet, only to be rebuilt after nearly all the water has passed on down stream.

If the water of this river is to be stored in Kansas this is the best way to do it.

Mr. Perry, of Englewood, Clark county, is storing the water of the Cimarron river in this way: He saturates his ground with water in the fall, and can raise a crop of wheat averaging thirty-five bushels per acre from this one watering. He irrigates 1200 acres.

Let us assume a farm somewhere near the 20 inch mean annual rainfall curve, with a draw on it having a drainage area of say twelve acres. And suppose the soil and inclination of surface is such that the run-off is 50 per cent of the mean annual rainfall. Then 50 per cent of 20 inches equals 10 inches, and this depth over twelve acres gives a volume of ten acre feet. If the average depth of the water in the reservoir is 10 feet, an area of one acre will be required to store it. We assume the evaporation to be 60 inches per annum, and the percolation one-fourth of this amount. These two lossses will then be 75 inches or 6¼ feet, leaving a depth of only 3¾ feet for irrigation.

The percolation loss we have assumed is perhaps too great. Reservoirs are made in western Kansas by a process called "puddling," which are nearly impervious to water, but it is necessary to keep the bottom and sides wet all the time, as if they get dry or freeze they crack. The sides and a part of the bottom of a reservoir storing rainwater will be dry a part of the time, and will leak some. By increasing the depth of the reservoir the surface exposed to evaporation is decreased, and the rate of evaporation somewhat diminished.

To the losses from the reservoir must be added those from the ditch carrying the water to the land.

The outlook for the storing of water in western Kansas is not very promising. In the central and eastern part, where the mean annual

rainfall is from 5 to 20 inches greater and the evaporation loss proportionately less, the case is quite different.

I am, of course, not referring to the sub-surface water, the underflow of the large rivers, and that of the Loup Fork Tertiary, the unshaded area on the map. These waters are already stored and only need to be brought to the surface. They are the hope of western Kansas, and yet not the only hope, for we believe that much of the surface water now unused, will in the future, when the demand for it is sufficiently great, be stored and used for irrigation.

# Diptera of Colorado and New Mexico.

BY W. A. SNOW.

## SYRPHIDÆ.*

The material on which the following list is based is derived chiefly from general entomological collections made by collecting parties sent out by the University of Kansas under the direction of Prof. F. H. Snow. The localities in which the greater part of the material was collected are: Bailey, Park county, Colo.; Estes Park, Larimer county, Colo.; Colorado Springs, Manitou, and Manitou Park, all in El Paso county, Colo.; and the Magdalena mountains, Socorro county, N. M. Bailey is a Union Pacific station on the Platte river at an altitude of 7,700 feet. Estes Park, shut in by high mountains, has an elevation of about 7,000 feet. Manitou Park is about twenty miles west of Manitou, on the Colorado Midland railroad, and but a few miles from the famous fossil beds of Florissant. Its altitude is 8,500 feet. Elevations in the Magdalena mountains vary from 6,500 to 10,000 feet. The Townsend collection furnishes a number of interesting species from Las Cruces, in southern New Mexico, altitude 3,800 feet. Others are derived from a large but indifferently preserved collection presented to the University of Kansas by Dr. G. F. Gaumer. Finally, I have availed myself of data furnished by the collections of Prof. C. P. Gillette, of Fort Collins, Colo.

**Callicera montensis** Snow, Kan. Univ. Quart. I, p. 34, pl. vii, fig. 1.

Taken only on mountain summits. The three specimens from which the description was drawn were collected on the top of Mt. Deception (9,000 ft.), Manitou Park, Colo., (August). Two more specimens were collected on the top of one of the mountains in the Magdalena range, New Mexico, at the head of Hop Canyon (9,500 ft.). Both were taken on the same day and subsequent attempts to find others were unrewarded. The genus *Callicera* is known elsewhere only at high altitudes in Europe.

**Microdon globosus** Fabr. (nec Will., Synopsis, p. 4 = *fuscipennis* Macq.).

*Microdon fuscipennis* Will., Synopsis, p. 4 (nec Macq.).

One specimen, Manitou Park, Colo. (August).

*For recent changes in synonymy, see a succeeding paper entitled "Supplementary List of North American Syrphidæ."

**Omegasyrphus** sp.

Male. Metallic green, slender species, with short antennæ, similar to *O. baliopterus* Loew and *coarctatus* Loew. Front narrowed in the middle, upper half very tumid, shining greenish black, with whitish erect pile; lower half depressed, flat, covered except in the middle with whitish appressed pile. Antennæ brownish black, very short; first joint short and rather thick, third joint hardly as long as the first, second joint one-half the length of the third; arista basal, short and slender. Face tumid, black with a slight greenish tinge, silvery pilose. Eyes bare, below with some very short, sparse, hardly perceptible pile. Thorax punctate, green, little shining, with a median geminate copper colored stripe and similarly colored lateral stripes. Scutellum concolorous, the tip emarginate and with two short spinous projections; metathorax metallic bluish black. Abdomen punctate, brassy metallic green, moderately shining; second segment wider than the others, with tumid sides. Pile of the whole body whitish, glistening. Legs fulvous brown, femora blackish, except at the base and at the tips; hind metatarsi thick, as long as the following joints. Halteres yellow. Wings cinereous hyaline, broadly infuscated along the veins; the costal, marginal, submarginal, and the first basal cells are almost altogether filled out with fuscous; the exterior end of the discal and first posterior cells are rounded posteriorly and from the latter there hangs the short stump of a vein.—Length 7 mm.

One specimen, Garden of the Gods, Colorado Springs, Colo. (July).

This species differs from *O. baliopterus* Loew, in general color and in the color of the front, which is black and not resplendant coppery; it has shorter antennæ, a widened second abdominal segment and no black pile on the sides of the abdomen; the fuscous black of the femora is not confined to the basal half. It is apparently distinct from *coarctatus* Loew, in its constricted front, shorter third antennal joint, and more infuscated wings.

**Chrysotoxum ypsilon** Will.

A single very large female from the Magdalena mountains, N. M. (July), measuring 17 mm., agrees almost perfectly with the description. The four front femora are black at the base. The three types were also from New Mexico.

**Chrysotoxum derivatum** Walk.

Ten specimens, Manitou Park, Colo. (July and August); four specimens, Estes Park, Colo. (August); one specimen, Colorado (Gillette, No. 544). A western and northern species. The characters used for separating the species in this genus are very unsatisfactory. They

pertain mostly to abdominal color differences and the relative length of the antennal joints. The study of a large number of specimens will undoubtedly lead to the rejection of some of the specific names now in use.

**Chrysotoxum integrum** Will.

A female from the Magdalena mountains, N. M., agrees best with the description of this species. *C. derivatum*, *laterale* and *integrum* are all very intimately related.—A southwestern species.

**Paragus bicolor** Fabr.

Two specimens, Manitou Park, Colo. (August), and one from Estes Park, Colo. (August), belong to Schiner's variety *tæniatus*. One, marked "Col." (Gillette, No. 1203), is nearest variety *ruficauda*. A specimen from Las Cruces, N. M. (Townsend, August 19), is variety *testaceus*. This species occurs across the continent as well as in Europe.

**Paragus tibialis** Fall.

Two specimens, Colorado Springs (July and August); three specimens, Colorado (Gillette, Nos. 1624, 1686, 1691). A species with a wide range like the preceding.

**Pipiza pistica** Will.

Two males and a female, Magdalena mountains, N. M. (August), and one male, Manitou (July), agree well with the description drawn from Connecticut specimens.

**Chrysogaster nigrovittata** Loew.

One male and two females, Colorado (Gillette, Nos. 413, 1204, 1700). The species is known only from the west.

**Chrysogaster bellula** Will.

One specimen, Magdalena mountains, N. M. (August); three specimens, Colorado Springs (August). Also a western species.

**Chilosia lugubris** Will.

A female from Colorado (Gillette, No. 1689), agrees sufficiently well with the description based on two males from California. The third joint of the antennæ is obtusely rounded at the end; the face is shining, bare, except for some sparse light pile along the orbits; the abdomen is everywhere equally shining; no yellow is apparent at the knees.

As the name *lugubris* is preoccupied by Zetterstedt for a Swedish *Chilosia*, I suggest that the specific name *willistoni* be conferred on this species.

**Chilosia sororcula** Will.

Described from males alone. The female differs in its shorter pile, more shining abdomen, and in a greater extent of yellow on the legs. Front about one-fourth of the width of the head, horizontally grooved above the antennæ; the abdomen wholly shining, except for a poorly defined opaque spot on the middle of the second segment.

More than one hundred specimens, Hop Canyon, Magdalena mountains, N. M. (August, 8000-8500 ft.). A southern form, first described from Mexico.

**Chilosia petulca** Will.

A single female, Colorado (Gillette, No. 687) is undoubtedly this species. The length is 7 mm. The wings are hardly more yellow at the base than elsewhere. Known hitherto from Washington (state).

**Chilosia tarda**, n. sp.

Male. Black, shining, somewhat metallic. Frontal triangle fossulate, very large, at its widest a third the width of the head, longer than the ocular line of contiguity, hardly shining, covered with yellowish cinereous pollen and long black pile. Antennæ small, reddish, third joint rounded; arista feebly pubescent, black. Face with sparse light pile along the orbits, and light pollen which is thickest just beneath the antennæ: a long rather shallow concavity above the tubercle and a very short abrupt one beneath it; tubercle more prominent than the antennal projection of the front. Eyes bare. Thorax and scutellum with long light pile, the latter without bristle-like hairs. Abdomen with long light colored pile, shining metallic black; first segment, second segment, except the lateral margins, and a large irregular posterior spot on the third segment, opaque. Legs black, tip of femora, base and tip of tibiæ, and basal joints of four front tarsi, yellowish red. Wings cinereo-hyaline.—Length 5.5 mm.

One specimen, Colorado (Gillette, No. 1556).

This species differs from *C. sororcula* Will. in its much larger frontal triangle, smaller antennæ, and in the abdominal characters.

**Chilosia lucta**, n. sp.

Female. Black, shining. Front plane, beset with very short, light colored pile. Antennæ velutinous black; arista black, incrassate for half its length, pubescent. Face shining black, very lightly pollinose beneath the antennæ; orbital pile white, very sparse and weak; the lower half of the face strongly produced, projecting beyond the antennal prominence; well defined concavities above and below the tubercle. Eyes bare. Pile of thorax short, seen from before yellow,

seen from behind mostly black. Scutellum destitute of long pile or bristly hairs. Abdomen altogether shining, with short light pile. Legs wholly black. Wings brownish, clearer toward the tip; veins fuscous; stigma indistinct. Tegulæ fringed with white pile.—Length 6 mm.

One specimen, Manitou, Colo. (July).

The species is perhaps nearest *C. nigripennis* Will., but differs in the protuberant face, lack of black pile on the face, the pubescent arista, the black color of the third antennal joint, and the white tegular fringe.

**Chilosia**, sp.

An injured female specimen, Colorado (Gillette, No. 1680), cannot be identified as previously described. Its general color is a brassy black. Eyes bare. Facial tubercle very obtuse and the concavities shallow; the face gradually projects from the antennæ to the epistoma. Pile of whole body short and sparse, light in color. Scutellum without bristly hairs. Legs black and reddish. Wings brown.

**Melanostoma stegnum** Say.

Nine specimens, Manitou Park, Colo. (August); seven, Estes Park, Colo. (July and August), all males. A single female, Colorado (Gillette, No. 1722). A southwestern species.

**Melanostoma cœrulescens** Will.

Two males, Estes Park, Colo. (August). Known only from Colorado.

**Melanostoma concinnum**, n. sp.

*Melanostoma*, n. sp. ? Snow, Kans. Univ. Quart. I, p. 35.

Male. Bluish or greenish metallic. Head dark blue, shining. Vertical triangle with white pile; frontal triangle with long, erect, dusky pile, and whitish pollen. Face prominent, with blackish pile, and thin white pollen, not or scarcely concave between antennæ and tubercle; tubercle and epistoma blackish, bare, both very distinct, about equally prominent; the pollen of the face is thin, not ripple-like or distinctly dotted; face in the middle without parallel transverse grooves, or wrinkles. Antennæ black; third joint yellowish below, oblong, as long as the two basal joints together. Thorax metallic dark blue, more bronze black on the dorsum behind the suture. Abdomen very narrow, widest at base, thence decreasing gradually in width to the tip, though often the third segment posteriorly is slightly wider than the second segment posteriorly. The color of the abdomen can best be described as shining metallic bluish green; the

second segment except the sides is opaque black, more broadly so behind; third and fourth segments, each with a large opaque black macula, in shape like an inverted goblet or wine glass; second and third segments with very narrow sometimes obsolete subrufescent posterior borders; fourth segment with shining metallic posterior border. Thus, the blue of the abdomen takes the form of lateral scallops on the second segment, and of interrupted anterior cross-bands on the third and fourth segments. The opaque portions do not reach the sides, though nearly so on the posterior portion of the segments. Pile of the whole body white. Legs testaceous; femora except the tip, a broad ring on the tibiæ, the hind tarsi, except sometimes the metatarsus, and the distal joints of the four front tarsi, black or fuscous; hind metatarsi enlarged; tibiæ without long bristles. Wings hyaline, stigma yellowish.—Length 6 to 8 mm.

Twenty specimens, taken near timber-line, Manitou Park, Colo., and Estes Park, Colo. (July and August, about 10,000 ft.); three specimens, Magdalena mountains, N. M. (August), are somewhat darker than the others.

Similar to *M. cœrulescens* Will., but distinguishable by the difference in color and shape of the abdominal markings, the lack of two yellowish lateral spots on the second segment, the shape of the second segment, which is distinctly narrowed distally and the absence of a row of bristly black hairs on the front femora. (Comparison drawn from a type of *cœrulescens* in the Kansas University collection).

**Melanostoma mellinum** Linn.

One female, Manitou Park, Colo. (August). Common to Europe and North and South America.

**Melanostoma kelloggi**, n. sp.

Male. Black. Frontal and vertical triangles very large and prominent; eyes contiguous for a very short distance, much shorter than the length of the vertical triangle; the latter with light pile, more dusky anteriorly; the frontal triangle, long, black pilose. Antennæ brown or fuscous brown. Face deep blue black and, together with the front, partially concealed between grayish yellow pollen; very prominent, not full or rounded as in *stegnum* and other species, but somewhat compressed, especially below, and with a large compressed tubercle; no rugose transverse markings; epistoma not prominent. Thorax black, anteriorly bluish black, posteriorly more bronze black. Abdomen not narrowed, black with yellowish brown markings as follows: first segment with a rather small round spot on each side; third and fourth segments with a pair of large square spots; the black of the fourth segment is more shining than that of the preceding seg-

ments; fifth segment and hypopygium shining black or bronze black. Legs (the hind pair are missing) yellow; the immediate base of the femora and the tarsal joints infuscated. Halteres of the same color as the legs. Wings hyaline, stigma yellowish.—Length 7 mm.

One specimen, Windy Gulch, Front Range, near Estes Park, Colo., (Prof. V. L. Kellogg, June 25, 11,000 ft.).

Distinct in its pinched face, narrow prominent tubercle, and large and prominent frontal triangle.

**Platychirus peltatus** Meig.

A single specimen, from Green Mountain Falls, Colo. (July). A northern species, hitherto recorded from northern Europe, Alaska and the mountains of New England.

**Platychirus chætopodus** Will.

One male specimen, Colorado (Gillette, No. 1709), agrees well with the description. The very insignificant facial tubercle scarcely shines through the covering of yellowish pollen; the outer angle of the distal end of the flattened front tibiæ is sublappet-like, though by no means as strongly produced as in *P. quadratus*. The species was described from Washington (state).

**Platychirus hyperboreus** Stæg.

One male specimen, Colorado (Gillette, No. 1709), is best placed here. The face is thinly pollinose, and the outer corner of the distal end of the front tibiæ is more produced than in Williston's figure (Synopsis, pl. III, fig. 12). The abdominal spots are smaller than in *quadratus* and the fifth segment is wholly black. A northern and mountain species.

**Platychirus palmulosus**, n. sp.

Male. Shining metallic greenish black. Face shining black with a very thin covering of grayish pollen and sparse light pile; tubercle rather prominent, much more so than in the two preceding species; frontal triangle more metallic greenish with yellowish pile and pollen. Antennæ dark brown, first joint darker. First segment of abdomen and hypopygium brassy greenish black; fifth segment wholly obscure, reddish; the reddish spots of second and third segments leave only very narrow or subobsolete hind borders and median stripes; black hind border of second segment also very narrow and the median stripe widened anteriorly where it reaches the lateral margins. Legs reddish yellow, hind femora and tibiæ with brown spots near the middle; hind metatarsi except the tip, black; last two hind tarsal joints brown; front tibiæ whitish distally, the outer angle of their distal end strongly

and widely produced, their metatarsi narrower than in related species; front femora with five or six long bristly black hairs in a row. Wings with a distinct brownish tinge.—Length 7 mm.

One specimen, Colorado Springs (August).

This species differs from related species in the yellow pile of the frontal triangle, the salient tubercle and the very thinly pollinose face. It differs further from *quadratus* and *hyperboreus* in the bristly cillia of the front femora, and from *chætopodus* in the more produced outer tip of the front femora.

**Catabomba pyrastri** Linn.

More than one hundred specimens, Colorado (Gillette, Nos. 780, 1744; F. H. Snow); Estes Park, Colo. (August); Colorado Springs (August); Magdalena mountains, N. M. (August, 6500 to 9000 ft.); Albuquerque, N. M. (August); New Mexico (Gaumer). Apparently more common in New Mexico than in Colorado. While this species is known from Europe, Africa, Chile, and the western states of North America, it has never been taken east of the Missouri river or south of the Rio Grande.

**Eupeodes volucris**, O. S.

More than one hundred specimens of both sexes, Manitou and Estes Parks, Colo. (July and August); Colorado Springs (August); Magdalena mountains, N. M. (August, 8000 to 9500 ft.); Las Cruces, N. M. (Townsend, in May, June, August); New Mexico (Gaumer). This species ranges from an altitude of 3000 or 4000 feet to one of 9500 feet or even higher. It is distinctly western and southern, coming no further east than western Kansas, and extending into old Mexico.

**Syrphus arcuatus** Fall.

One male and three females, Manitou Park, Col. (Aug.); two females, Colorado (Gillette, Nos. 1531 and 1607); four males and two females, Magdalena mountains, N. M. (Aug.); one female, New Mexico (Gaumer). A northern species, especially, and common to Europe.

**Syrphus intrudens** O. S.

One male specimen, Estes Park, Col., (Aug.), agrees only fairly well with the description. The black facial stripe is considerably broader than the yellow portion of the face on each side of it; antennæ dark brown, third joint reddish below; pile of the occiput yellowish gray; pile of the scutellum yellowish; the abdomen is very shining, less so on the second segment.—Length 7 mm. The species was described from California.

**Syrphus disgregus**, n. sp.

Male, female. Eyes pilose. Antennæ black. Face greenish yellow with black stripe. Three bands of abdomen interrupted.—Length 6—8 mm.

Male. Head black. Vertical triangle with light colored, and frontal triangle with black, pile; the latter yellowish gray pollinose, except on the middle and anteriorly. Antennæ black or fuscous black. Face of a bright greenish yellow, with a narrow median black stripe which does not reach the antennæ, and sparse black pile on the sides; tubercle large; oral margin bordered with black; cheeks broadly black. Eyes pilose. Occiput grayish pollinose and with yellowish gray pile. Thorax shining metallic greenish black, covered with long, altogether light colored pile. Scutellum bright yellowish brown with scarcely any opalescent reflections; pile long, black distally, and light colored on basal half. Abdomen black, a little shining, with greenish yellow spots which in drying may become more yellowish or brownish, especially on the distal segments; spots of first segment round, sometimes a little oval, separated from the lateral margins; second and third segments each with a pair of sublunate spots which reach the lateral and sometimes the anterior margins; the inner ends of these spots are enlarged and round, the outer ends scarcely at all enlarged, and square; the emargination of the spots is not very deep; fourth and fifth segments with narrow greenish yellow posterior bands, the latter with spots of the same color in the anterior corners. Pile of abdomen black except on the basal and yellow portions; hypopygium metallic black, slightly greenish. Halteres with a greenish yellow knob. Legs brownish, anterior femora black on their proximal half; hind femora black, except the tip; distal half of hind femora, the hind tarsi, and the three middle joints of the anterior tarsi, fuscous brown; anterior tibiæ occasionally partly brown near their middle. Wings almost hyaline, sometimes slightly tinged with brown; stigma brown.

Female. Front black, upper third and vertex bronze black, very shining; across the middle with a broad fulvous narrowly interrupted pollinose band which extends along the sides as far as the antennæ, leaving just above the latter a shining black area; sparse pile of front black. Abdomen more broadly oval than in the male; the lunate spots on the second and third segments reach the anterior margin, which in the male they rarely do except sometimes those of the fourth segment; sixth segment with a greenish yellow hind border. Legs slightly lighter than those of the male. Wings of a brownish tinge.

Twenty-three males and thirty females, Hop Canyon, Magdalena mountains, N. M., (July to Aug., 7500—8500 ft., on flowers of a species of *Geranium*).

This species is similar to *intrudens* O. S. but differs in the color of the front, face, occipital, thoracic and scutellar pile, and of the scutellum; differs also in the shape of the abdominal spots; it is smaller. It is still further removed from *amalopis* O. S. In none of the numerous specimens do the lunate spots show a tendency to divide into two.

**Syrphus disjectus** Will.

One female specimen, Manitou Park, Colo. (Aug.).—Described from state of Washington specimens.

**Syrphus ruficauda** Snow, Kan. Univ. Quart., I, p. 36, pl. vii, fig. 3.

Four males and one female, Manitou Park, Colo. (July and Aug., 9000 ft.); two males, New Mexico (Gaumer). One of the Colorado males which was overlooked when the description was drawn, measures but 6 mm. The largest male is 9 mm. in length. A very distinct species in its bright red fourth and fifth abdominal segments.

**Syrphus creper** n. sp.

*Syrphus pauxillus* Snow, l c. p. 37* (nec Will.)

? *Syrphus lotus* Will. var., Synopsis, p. 75.

Male, female. Related to *pauxillus* Will. Eyes pilose; the abdominal spots do not reach the lateral margin, those of the third and fourth segments arcuate.—Length 7 to 9 mm.

Male. Frontal and vertical triangles black, with black pile, the former grayish pollinose except in the middle anteriorly. Antennæ black; the third joint brownish, reddish below. Face prominent, yellow, with a strong greenish tint; in the middle and along the oral margin black; the facial stripe is much narrower than the yellow portions on each side of it; cheeks brownish yellow, above with a broad black stripe; sides of face with sparse black pile. Eyes pilose. Occiput with a fringe of whitish hair. Thorax metallic greenish black, on the dorsum with three well separated narrower darker stripes; pile yellowish. Scutellum brown, basal angles and border of metallescent greenish black. Abdomen a little shining, with yellow spots which in the best preserved specimens have a greenish tint; spots of second segment straight, slightly oblique, more than twice as long as wide, widely separated from each other and the lateral margin; spots of third segment oblique, arcuate, concave before and convex behind, reaching the lateral and falling short of the anterior margin (except in rare cases), separated from each other more or less widely (rarely joined together), truncate at both ends, widened but not rounded at the

*In line 3 of the page indicated above, the words male and female should be made to change places.

inner end; spots of fourth segment similar but generally joined together and always resting broadly upon the anterior margin; fourth and fifth segments more shining than the preceding with narrow yellow or light green hind borders. Halteres with a greenish yellow knob. Legs yellow, with the distal half of the anterior femora, nearly the whole of the hind femora, a more or less broad ring on the hind tibiæ and the hind tarsi except the basal joint, black; anterior tarsi brownish. Wings hyaline or slightly brownish; stigma brown.

Female. Front gradually narrowed from antennæ to ocelli where it is distinctly narrower than half the length of the front, shining black, across the middle with a broad uninterrupted arcuate band of yellow pollen; fifth segment of abdomen with a yellowish spot in the anterior angles.

Thirteen males, top of Deer mountain, Estes Park, Colo. (Aug); seven males and two females, Hop Canyon, Magdalena mountains, N. M., (Aug., 7500 to 9500 ft.).

This species differs from the description of *pauxillus* Will. (Synopsis, p. 74) in the color of the face, cheeks and thorax; the abdomen is obsoletely shining except on the last segment; the lunate spots of the abdomen are not of equal width; the distance from ocelli to antennæ is not distinctly less than that from antennæ to the tip of the tubercle. The two species must however bear a marked resemblance to each other.

**Syrphus ribesii** Linn.

Five specimens, Manitou Park, Colo. (Aug.); twenty specimens, Hop Canyon, Magdalena mountains, N. M. (Aug., 8000 ft.). In the latter locality the species became rather common only toward the end of August, and at a considerable altitude. A female from Colorado (Gillette, No. 1752) is remarkable in that the abdominal bands are all distinctly interrupted.—Common to Europe and South America.

**Syrphus** sp.

Related to *torvus*. Eyes pilose; cheeks yellow; scutellum yellow; the abdominal spots reach the lateral margins broadly.

Female. Differs from *torvus* as follows: Face with a short black stripe on the tubercle; the blackish brown arch above the antennæ has no projecting angle in the middle; antennæ uniformly black; thorax with considerable luster; the yellow spots on the second abdominal segment reach the lateral margin in nearly their full width and are not prolonged in a neck; yellow crossbands of the third and fourth segments are strongly biconvex on their hind margins, with a deep sinus in the middle; they are scarcely attenuated on the sides,

but reach the margin in nearly their full width; the black interval between the stripes is about equal in width to the stripes.

One specimen, Magdalena mountains, N. M. (Aug.).

**Syrphus americanus** Wied.

More than two hundred specimens, Manitou Park, Colo. (July, Aug.); Estes Park, Colo. (Aug., at high altitudes); New Mexico (Gaumer); Magdalena mountains, N. M. (Aug., 7500—9500 ft.). This large series of specimens shows considerable variation in some respects, but I am not able to separate individuals exhibiting extremes of variation on account of the intergradations. With a good simple lense, sparse short pubscence is observable upon the eyes of all the males, including those from more eastern localities (Kans., Ill., Fla.). This pubescence is more marked on individuals which were taken at high altitudes. The spots above the antennæ may be obsolete, faintly brown, or large and deep black; in general they are fainter in the specimens taken at high altitudes. The facial stripe shows every degree of development and is frequently absent. The pile on the sides of the face is black, or black and yellow mixed, or yellow except near the antennæ. In specimens from the lower altitudes this pile is generally wholly black. The spots of the second abdominal segment reach the lateral margin in many cases, sometimes broadly.

Several of these variable characters are used by Osten Sacken to distinguish *abbreviatus* from *americanus*, which differ chiefly in the color of the cheeks, a character also mentioned by him.—A common species all over the country.

**Syrphus opinator** O. S.

One male, Manitou Park, Colo.; ten males, Magdalena mountains, N. M. (Aug.). A distinctly western species, very similar in appearance to *americanus*. The eyes are also very feebly pubescent. The wholly yellow cheeks, narrow abdominal bands of the third and fourth segments which do not reach the margin, and the rather bright yellow scutellum, will distinguish the species.

**Syrphus montivagus**, n. sp.

Eyes bare; no facial stripe; cheeks black; oral margin very widely black; scutellum scarcely lighter than the thorax; the reddish yellow abdominal spots or bands do not reach the margin, those of the third and fourth segments interrupted or connected; these bands are very wide; femora black at the base.

Male. Front and face brownish yellow; the former rather prominent, black pilose and whitish pollinose except in the middle anteriorly; no dark spots above the antennæ. Antennæ dark brown, third

joint reddish below. Face on the sides with thin light colored pile except above, where the black pile of the front descends below the antennæ; cheeks greenish black; on the face in front of the cheeks and around the oral margin, broadly black; tubercle brown, sometimes darker; the dark color does not extend above the tubercle as a stripe. Occiput with a fringe of fulvous pile. Thorax metallic bluish black, with rather thick golden yellow pile. Scutellum not much darker than the thorax. Abdomen broadly oval, a little shining, on the fourth and fifth segments more shining; the spots or bands of the abdomen are brick red, those of the second and sometimes of the third segments more reddish yellow; they are all well separated from the lateral margins; spots of the second segment rather small, oval or subtriangular; spots of the third and fourth segments about two-thirds of the width of the segment, often widely interrupted, especially those of the third segment, and frequently forming an uninterrupted or subinterrupted emarginate band; both bands nearly touch the anterior margin of their segments; the wide posterior border of the fourth and all of the fifth segment, brick red; the shining portions of the abdomen generally show a distinct blue reflection. Legs brownish, basal half of front and middle femora, and basal two-thirds of hind femora black; median joints of hind tarsi dark brown. Wings hyaline, at the base and near the costa with a brownish tinge.—Length 7.5—10 mm.

Forty-five males taken above timberline (between 11,000 and 12,000 ft.) on Mt. Hallett, near Estes Park, Colo. (Aug.).

A well marked and easily distinguishable species.

**Syrphus umbellatarum** Schin.

Five females, Manitou Park, Colo. (Aug ); one female, Magdalena mountains, N. M. (Aug.).—Known also from the White mountains, N. H., and Arizona.

**Syrphus pullulus**, n. sp.

Male. Eyes bare. Front black, covered with grayish pollen except anteriorly, and black pilose. Antennæ black. Face brownish yellow with blue reflections, on the sides whitish pollinose and black pilose; in the middle with a black stripe which extends broadly along the oral margin to the black cheeks. Occiput white pilose. Thorax greenish black, but little shining; pile mostly obscure fulvous. Scutellum brown, darker at the basal angles, with a distinctly metallic blue reflection, clothed with long black pile. Abdomen considerably narrower than the thorax, with almost parallel sides and three pairs of rather small, transverse yellow spots, very much as in *umbellatarum*; opaque, fifth segment subopaque, first segment and hypopygium shin-

ing greenish black; spots of second segment small, oblong or triangular, situated a little anterior to the middle of the segment; spots of third and fourth segments subquadrate, removed from the anterior border of the segment by about half their width; the spots are widely separated from each other and do not reach the lateral margin of the segments; fourth and fifth segments with a narrow yellow posterior margin. Legs black, tip of front and middle femora and front tibiæ, except a brownish ring, yellowish brown. Wings hyaline, faintly tinged with yellow; stigma brownish.—Length 8—9 mm.

Four males, Magdalena mountains, N. M. (Aug., 8000 ft.).

The species is to be distinguished from *umbellatarum* by the black cheeks and by the less regularly quadrate shape of the abdominal spots.

**Didea fuscipes** Loew.

A male and a female from the Magdalena mountains, N. M., (Aug.). The male was taken near the top of "Little Baldy" (9500 ft.); the female, in Hop Canyon (at about 8000 ft.) There seems to be no previous record of the capture of this species west of Pennsylvania.

**Didea laxa** O. S.

A single female, Hop Canyon, Magdalena mountains, N. M. (Aug., at about 8000 ft.).—Occurs across the country in mountainous regions.

**Xanthogramma habilis**, n. sp.

Female. Upper part of the front metallic greenish black, emitting a stripe of the same color, which for most of its length is distinctly more than one-third the length of the front, but anteriorly it is abruptly narrowed; sides of front deep yellow. Antennæ dark brown, first joint lighter. Face and cheeks pale yellow with no darker markings. Pile of occiput silvery white, near the vertex yellow. Thorax with well defined pale yellow lateral stripes and two large coalescent spots of the same color before the scutellum; scutellum wholly subtranslucent yellow, except on the sides near the base. Abdomen no wider than thorax, subopaque, black; first segment with a large yellow spot under the halteres; segments 2—5, each with a pair of widely separated yellow spots which do not reach the lateral margins of the segments, except those on the fifth; spots of the second segment nearly round and about in the middle of the segment; those of the third and fourth segment straight, subquadrate, and near the anterior margin of the segment; the spots of the fifth segment are in the anterior angles; fourth and fifth segments with a narrow yellow hind border. Legs yellowish, front and middle femora with a basal blackish ring, hind femora black except the base and tip; hind tibiæ

with a blackish ring; the hind tarsi black. Wings hyaline, the stigma faintly yellowish.—Length scarcely 6 mm.

A single female, Magdalena mountains. N. M. (Aug.).

The species is easily recognizable by the yellow markings of the thorax, the yellow scutellum, the broadly interrupted abdominal band, the lack of a dark costal border of the wings, and by its small size.

**Allograpta obliqua** Say.

Many specimens, bearing labels as follows: Manitou Park, Colo. (Aug.); Colorado Springs; Cheyenne Canyon, Colo. (July); Colorado (Gillette, No. 1722); Magdalena mountains, N. M. (Aug.); Albuquerque, N. M. (Aug.); New Mexico (Gaumer). Occurs accross the continent and into South America, and has been taken above timber line in Colorado.

**Mesogramma marginatum** Say.

Manitou Park, Colo. (July, Aug.); Colorado Springs and Garden of the Gods, Colo. (July); Colorado (Gillette, Nos. 1650, 1699); New Mexico (Gaumer); Las Cruces, N. M. (Townsend, June 3, 5; Aug. 21); Albuquerque, N. M. (Aug.); Magdalena mountains, N. M. (July and Aug.). A very common species all over North America.

**Mesogramma politum** Say.

Two males, Magdalena Mountains, N. M. (Aug.).—Has a very wide distribution in this continent.

**Sphærophoria cylindrica** Say.

Numerous specimens showing much variation in the color of the abdomen, Manitou and Estes Parks, Colo. (July, Aug.); Colorado Springs and Garden of the Gods, Colo. (July and Aug.); Colorado (Gillette, Nos. 1666, 1685, 1709, 1722); New Mexico, (Gaumer); Las Cruces, N. M. (Townsend, Apr. 8); Magdalena mountains, N. M. (Aug.).—Occurs from east to west.

**Pelecocera willistoni** Snow, Kans. Univ. Quart., III, p. 187.

The two types were taken in the Magdalena mountains, N. M. (Aug.).

**Baccha clavata** Fabr.

One male, Albuquerque (last week of Aug.); one female, Las Cruces, N. M. (Townsend, June 7).—A southern species from Florida to California, and extending into South America.

**Baccha lemur** O. S.

One female, Estes Park, Colo. (Aug.); one male, Colorado (Gillette, No. 780); two females, Magdalena mountains, N. M. (Aug.); one male, Las Cruces, N. M. (Townsend, June 7th).—Distinctly western.

**Baccha obscuricornis** Loew.

A single male, Magdalena mountains, N. M. (Aug.), agrees very well with the description. The antennæ are light brown, very small, the third joint wider than long.—Described from Alaska; also known from California.

**Rhingia nasica** Say.

One specimen, a small male, Manitou Park, Colo. (Aug.).—A common eastern species.

**Brachyopa cynops** Snow, Kans. Univ. Quar., I, p. 37.

The single type specimen is a female and was taken in Manitou Park, Colo. (Aug.). The epistoma is abruptly projected like a tubercle.

**Brachyopa vacua** O. S.

A male, Manitou Park, Colo. (Aug.), agrees throughout with the description.—Recorded previously from Canada and California.

**Volucella facialis** Will.

One male specimen, Colo. (Gillette No. 687).—A Californian species.

**Volucella esuriens** Fab.

Two specimens, Hop Canyon, Magdalena mountains, N. M. (Aug., 7,500 ft.); Las Cruces, N. M., (Townsend, Aug. 21). Both are variety *mexicana*. Peculiarly a southern species.

**Volucella comstocki** Will.

Ten males and fourteen females, Magdalena mountains, N. M. (Aug., 9,000-10,000 ft.); one male and two females, Las Cruces, N. M. (Townsend, Apr. 18); two males and nine females, New Mexico (Gaumer). Williston gives 12 mm. as the size of the species. In these specimens the average size is 9.5 mm., the largest measuring 11 and the smallest 8 mm. The types were from Arizona and New Mexico.

**Vulucella anna** Will.

One hundred and forty specimens, the sexes about evenly divided, Magdalena mountains, N. M. (July, Aug., 7,000 to nearly 10,000 ft., in greatest abundance at an elexation of about 9,000 ft.); one female, Las Cruces, N. M. (Townsend, Apr. 18); several specimens; New

Mexico (Gaumer). The species resembles *comstocki*, but is very distinct in its more protuberant face, more dull coppery black color of body, wings infuscated at base, and greater size. In the latter respect there is considerable variation, the smallest individual measuring 9.5 and the largest 14 mm.

The species was described from a single male from Arizona. In the female the eyes are rather thickly pilose; the front is somewhat narrowed above, chestnut colored, sometimes darker, pile mostly black, on each side with a well marked concentric groove.

**Volucella avida** O. S.

Ten males and seven females, Magdalena mountains, N. M. (Aug., 9,000 ft.). Found in company with the two preceding species.

**Volucella isabellina** Will.

A female from Las Cruces, N. M. (Townsend, July 12). The type was from Arizona.

**Volucella satur** O. S.

Two males, Colorado (F. H. Snow; Gillette, No. 788); one female, Estes Park, Colo. (Aug.); a male and a female, Magdalena mountains, N. M. (Aug.); nine males and two females, New Mexico (Gaumer).—A western species.

**Volucella tau** Big.

One male, Colorado (F. H. Snow); one female, New Mexico (Gaumer).—Southwestern.

**Volucella obesa** Fabr.

One specimen, New Mexico (Gaumer).—Throughout the tropical regions of America.

**Volucella fasciata** Macq.

Two females, Colorado, and Manitou Park, Colo. (July).—A western and southern species.

**Volucella haagii** Jænn.

Twenty males and twenty-eight females, Magdalena mountains, N. M. (July, Aug., 7,000 to nearly 10,000 ft.). Taken in company with *comstocki*, *anna*, and *avida*.—A southwestern species.

**Volucella apicifera** Towns., MS.

A typical specimen, Las Cruces, M. M. (Townsend, Apr. 7). A large light colored species with the distal half of the third and all of the fourth abdominal segment, black.

**Copestylum marginatum** Say.

Colorado (F. H. Snow; Gillette, Nos. 770, 788); Manitou Park, Colo. (Aug.); New Mexico (Gaumer); Las Cruces, N. M. (Townsend,

April 18, May 23); Magdalena mountains, N. M. (Aug., 9,000 ft.) From the latter locality are thirty males and twenty-eight females taken along with certain species of *Volucella*. The females are all light colored and show the yellow thoracic markings distinctly, while the males without exception belong to Williston's dark variety *lentum*. This would indicate that the differences between these forms are sexual rather than varietal, since both were taken at the same time and place. A western and southern species.

**Sericomyia militaris** Walk.

Eight males and six females, Manitou Park, Colo. (July, Aug.); four males and one female, Estes Park, Colo. (Aug.); one male, Colorado (Gillette, No. 788); one male, New Mexico (Gaumer). *Sericomyia* is a northern genus and specimens from localities to the south of Colorado are rare.

**Arctophila flagrans** O. S.

Eighteen males and four females, Manitou Park, Colo. (July, Aug., on the tops of mountains); fifteen males, Estes Park, Colo. (Aug., at high altitudes); one female, Colorado (Gillette No. 788); four males, Magdalena mountains, N. M. (Aug., on top of "Big Baldy" mountain, 10,000 ft.); twenty males, New Mexico (Gaumer). So far as I know this species is taken only on the summits of mountains of considerable height.

**Eristalis tenax** Linn.

Manitou Park, Colo. (July); Estes Park, Colo. (Aug.). Common all over the world.

**Eristalis hirtus** Loew.

Over one hundred specimens, Bailey, Colo. (Aug.); Manitou Park, Colo. (July, Aug.); Estes Park, Colo. (Aug.); Manitou, Colo. (Aug.); Colorado (F. H. Snow; Gillette, No. 823); five specimens, Magdalena, mountains, N. M. (Aug.). This species is seemingly much more common in Colorado than in New Mexico. It is distinctly western.

**Eristalis latifrons** Loew.

More than two hundred specimens, Bailey, Colo. (Aug.); Manitou Park, Colo. (July, Aug.); Estes Park, Colo. (Aug.); Colorado Springs (Aug.); Colorado (F. H. Snow; Gillette, No. 1722); New Mexico (F. H. Snow; Gaumer); Las Cruces, N. M. (Townsend April 8, 9; June 7-28); Albuquerque, N. M. (Aug.); Magdalena mountains, N. M. (Aug.). In the latter locality this species ranged up to 10,000 feet and was most numerous at about 9,000, in company with several species of *Syrphus*, *Volucella* and *Copestylum*. Another western species.

**Eristalis brousi** Will.

Four males and two females, Manitou Park, Colo. (Aug.); fourteen males and five females, Colorado Springs (July, Aug.); two males and four females, Colorado (Gillette, Nos. 822, 1331, 1722). In several of the females the lateral spots of the second abdominal segments are yellow and distinct, occasionally extending a short distance upon the third segment. The species occurs all over North America.

**Eristalis flavipes** Walk.

A single female, Colorado (Gillette; Coll. Townsend); has a broad, black pilose, posterior thoracic band. This species is well distributed across the continent.

**Eristalis transversus** Wied.

A single female, Manitou Park, Colo. (Aug.). The species is recorded in Williston's Synopsis as from the Atlantic States only. I have taken it also in Illinois and Kansas.

**Helophilus latifrons** Loew.

Bailey, Colo. (August); Manitou Park, Colo. (July, August); Colorado (Gillette, Nos. 1331, 1710); Colorado Springs (August); Albuquerque, N. M. (August); Las Cruces, N. M. (Townsend, June 8); New Mexico (Gaumer). Not as common in New Mexico as in Colorado. It extends across the continent.

**Helophilus similis** Macq.

A single female specimen from Manitou Park, Colo. (August).

**Helophilus lætus** Loew.

A female from Colorado Springs (August) agrees well with Williston's description (Synopsis, p. 189). The fulvous band of the fourth abdominal segment is subinterrupted, does not touch the anterior border of the segment along its whole length, and bears a light pollinose spot on the inner ends of its two halves. Previously recorded east of Illinois.

**Helophilus** sp.

A female specimen from Manitou Park, Colo. (July) belongs to the *grœnlandicus* group. From that species it shows the following differences: head somewhat produced, the lower border of the cheeks forming an obtuse angle with the occiput; the slender median thoracic stripes reach the scutellum; pile of the thoracic dorsum entirely yellow; scutellum with only a few black hairs on the middle of the disk; tip of the middle femora yellow.

It differs from *glacialis* in the complete median thoracic stripes, in the less shining color of the abdomen, which is confined to the pos-

terior borders of the segments; in the wider interruption of the second segmental fascia; and in the greater extent of black pile at the lateral posterior angles of the segments.

From *borealis* it is distinguishable by the greater distinctness of the median thoracic stripes; by the yellow lateral portion of the whitish abdominal fasciæ on the third segment, which in this specimen reach the lateral margin; by the shorter whitish spots of the fourth segment which do not attain the lateral margin; and by the lack of a distinct longitudinal groove in the hind femora of the female.

**Mallota albipilis.** n. sp.

Female. Black, pile everywhere yellowish white. Face and front thickly covered with whitish yellow pollen which has a darker shade on the front; median stripe of face and the cheeks shining black, except a small red spot immediately beneath the eyes. Antennæ dark brown, third joint broader than long, rounded; arista yellow. Eyes bare. Pile of the disk of the mesonotum more yellow, than upon the margins and pleura; the dorsum thickly covered with dark yellow pollen through which two slender median and two broad interrupted lateral stripes show obscurely. Scutellum yellow, with long whitish pile. Abdomen somewhat longer than the thorax, arched, shining black, appearing almost bare, the thin whitish pile being most noticeable at the sides. Legs shining black or brownish black, the tarsi lighter; pile altogether whitish. Basal half of wings hyaline, distal half faintly infuscated; an obscure median subfasciate brown spot.—Length 11 mm.

One female specimen, Las Cruces, N. M. (Townsend, June 9).

Distinct in its light colored short pilosity, and almost bare abdomen. It resembles *Brachypalpus* in form.

**Tropidia incana** Towns., MS.

The type of the species, a female, is from Colorado (Gillette, No. 138).

**Xylota analis** Will.

Two males, Hop Canyon, Magdalena mountains, N. M. (July, August, 8500 ft.). Recorded also from California.

**Xylota flavitibia** Big.

Six males and two females, Manitou Park, Colo. (July, August); one male, Colorado, (Gillette, No. 537); one male, Magdalena mountains, N. M. (August). Described from Colorado.

**Xylota ejuncida** Say.

Three females, Colorado and Magdalena mountains, N. M. (August, 8500 ft.). Known over the whole United States.

**Syritta pipiens** Linn.

Abundant, except at the higher altitudes, in the following localities: Idaho Springs, Bailey, Manitou Park, Colorado Springs, Estes Park, in Colorado; Albuquerque, Las Vegas, Santa Fe, Socorro, Magdalena mountains, Las Cruces, in New Mexico.—Common to the whole United States, Europe, Asia, Africa.

**Chrysochlamys crœsus** O. S.

Four specimens, Colorado; over a hundred specimens, mostly males, Hop Canyon, Magdalena mountains, N. M. (July, August, 7000 to 9500 ft.). In the latter locality they were numerous from 8 to 10 o'clock a. m. in the canyon at an elevation of something less than 8000 feet. At this time the males could be taken as they flew around, or alighted upon, the trunks of large spruce trees, always choosing the sunny side. A few specimens were collected near the top of a mountain which rises to about 9500 feet. A western species.

**Spilomyia liturata** Will.

Five males and one female, Magdalena mountains, N. M. (August, over 9000 ft.), are best placed here. The type was from New Mexico.

**Spilomyia kahli** n. sp.

Male. Yellow, red and black, variegated. Vertical triangle reddish brown, more yellow on the lower part; frontal triangle yellow, near the orbits with silvery pollen; antennal process reddish brown, on under side yellow. Antennæ reddish brown, second joint one and a half times the length of the first, third joint a little broader than long. Face yellow with no median stripe; cheeks and oral margin reddish brown; proboscis blackish. Occiput, except just below the vertex, black. Thorax black, subopaque; humerus, a large triangular spot on its inner side, and ante-alar callosity, yellow; a broad reddish lateral stripe from the scutellum to the suture includes the post-alar callosity and touches the ante-alar callosity; just before the scutellum is a broad crescentic subinterrupted reddish spot, so broad that only a sublinear black space separates it from the scutellum; a large mesopleural spot reddish, a smaller sternopleural spot just below the former and a spot below the tegulæ, yellow. Scutellum wholly reddish brown. Abdomen hardly as wide as the thorax, widest at the second segment, strongly convex above; first segment

black, on the sides red; second segment with a yellowish or reddish band subinterrupted in the middle (where it is about one-sixth the width of the segment, and does not quite reach the anterior margin), on the sides strongly dilated, extending from the anterior nearly to the posterior margin; behind this band the segment is black in the middle and brown on the sides; third segment similar to the second except that posteriorly it is broadly reddish or brownish; fourth segment wholly yellow, except narrowly in front; hypopygium brown. Legs reddish brown, basal half of tibiæ yellow, hind femora above and behind black, except at the base and tip. Wings subhyaline, brown on the anterior half, the costal cell is hyaline and the first and second basal cells are brown.—Length 11 mm.

One specimen, taken by Mr. Hugo Kahl near the summit of "Little Baldy" in the Magdalena range, N. M., an altitude of more than 9000 feet (August).

A very beautiful species and markedly different from its congeners.

**Ceria abbreviata** Loew.

A female specimen from Colorado (Gillette, No. 593) agrees very well with specimens from the White mountains, N. H. The third antennal joint is brownish rather than black and the scutellum is almost entirely yellow. Known hitherto from New England, Virginia, Florida.

**Ceria tridens** Loew.

A male and a female, Las Cruces, N. M. (Townsend: male, April 8; female, June 21).—A western species.

**Ceria townsendi**, n. sp.

Red species, varied with yellow. Face yellow; antennal process less than half the length of the first antennal joint; dorsum of mesonotum black; scutellum yellow; second abdominal segment narrowed basally; second, third and fourth segments with yellow posterior bands; the slight angle of the last section of the third longitudinal vein emits a stump of a vein into the posterior cell.

Male. Face with a slight tubercle; yellow; in the middle with a ferruginous stripe concolorous with and proceeding from the short antennal process; this median stripe is widest nearest its middle and bounded laterally by two narrow blackish stripes that come together at the oral margin; just before the yellow cheeks are two distinctly separated oblique black stripes proceeding from eye to oral margin. Antennæ brown, first joint reddish, slender, nearly as long as the two following joints together; third joint distinctly shorter than the second. Vertex yellow, swollen; ocellar area blackish; frontal triangle shining

black except along the orbits, where it is yellow. Thorax black, pleura more reddish; humeri, ante-alar callosity, a short slender stripe between the latter and the post-alar callosity, the scutellum, except the immediate base, a long mesopleural spot and a contiguous sternopleural one, and a large spot under the tegulæ, yellow. Abdomen reddish; second segment narrowly cylindrical at the base, much wider posteriorly, and with a yellow hind border; third and fourth segments with a similar band, that of the latter broader; fourth segment longer than the third, covered with grayish pollen, through which the reddish brown color shows in many small round spots; hypopygium reddish. Legs reddish, basal half of the tibiæ yellow, tarsi fulvous. The brown of the anterior portion of the wing is limited by the third longitudinal vein.—Length 9 mm.

One specimen, Las Cruces, N. M. (Prof. C. H. Tyler Townsend, April 18).

## Additional Species Hitherto Recorded from Colorado and New Mexico.

**Nausigaster punctulata** Will.—N. M.
**Chilosia lasiophthalma** Will.—Colo.
**Chilosia comosa** Loew.—Colo.
**Platychirus ciliatus** Big.—Colo.
**Syrphus amalopis** O. S.—N. M.
**Syrphus pauxillus** Will.—N. M.
**Syrphus sodalis** Will.—Colo.
**Volucella victoria** Will.—N. M.
**Eristalis scutellaris** Fabr.—N. M.
**Helophilus obscurus** Loew.—Colo.
**Helophilus bilinearis** Will.—Colo.
**Triodonta curvipes** Wied.—Colo.
**Crioprora cyanogaster** Loew.—Colo.
**Brachypalpus parvus** Will.—Colo.
**Xylota pigra** Fabr.—Colo.
**Xylota notha** Will.—Colo.
**Xylota metallifera** Big.—Colo.
**Xylota coloradensis** Big.—Colo.
**Temnostoma æquale** Loew.—Colo.
**Sphecomyia vittata** Wied.—Colo.

# Supplementary List of North American Syrphidæ.

BY W. A. SNOW.

The following species of Syrphidæ have been discussed from a systematic and faunal standpoint, or described as new since the publication of Dr. Williston's Synopsis in 1886.

### CALLICERA.

montensis Snow., **J**, p. 34, pl. VII, fig. 4; antea, p. 225.—Colo., N. M.

### MIXOGASTER.

bellula Will., **B**, p. I, pl. I, figs. 1, 1a, 1b.—Mex.
dimidiata G.-T., **F**, p. 1; **H**, p. 33, pl. I, figs. 9, 9a.—Mex.
mexicana Macq., Will., **B**, p. 1.—Mex.

### MICRODON.

aquilinus G.-T., **F**, p. 2; **H**, p. 36.—Mex.
aurifex Wied.; Will., **B**, p. 2, pl. I, figs. 2, 2a.—Mex.
aurulentus Fabr.; G.-T., **H**, p. 35.—Mex.
*Microdon crassitarsis* Macq.; F. Lynch A., **D**, p. 30. [G.-T.].
?*Microdon macquartii* F. Lynch A., **D**, p. 30. [G.-T.].
falcatus Will., Synopsis, p. 9; **B**, p. 3; G.-T., **H**, p. 36.—Mex.
globosus Fabr.; Snow, antea p. 225.—Colo.
*Microdon fuscipennis* Will, (nec Macq.) Synopsis, p. 4. [Will.].
gracilis Big.; Will., **B**, p. 3.—Mex.
megalogaster Snow, **J**, p. 34, pl. VII, fig. 1.—Ill.
niger Will., **B**, p. 4, pl. I, figs. 3, 3a.—Mex.
sp. Will., **B**, p. 4, 5.—Panama.
sp. Will., **B**, p. 4, 6.—Guatemala.

### OMEGASYRPHUS.

baliopterus Loew.; Will., **B**, p. 3.—Mex.
coarctatus Loew.; Will., Synopsis, p. 6, (*Microdon*); G.-T., **E**, p. 3; **H**, p. 39, pl. I, fig. 11.
sp. Snow, antea, p. 226.—Colo.

### RHOPALOSYRPHUS.

güntherii F. Lynch A., **D**, p. 39, (*Holmbergia*); l. c., p. 152; G.-T., **E**, p. 2; **H**, p. 35, pl. I, figs. 10, 10a, 10b.—Argentina, Mex.

### UBRISTES.

chrysopyga G.-T., **F**, p. 1; **H**, p. 37.—Mex.

### CHRYSOTOXUM.

derivatum Walk.: Snow, **J**, p. 34; antea, p. 226.—Colo.
integrum Will., Synopsis, p. 16; **B**, p. 5; G.-T., **H**, p. 39; Snow, antea, p. 227.—Mex., N. M.
ypsilon Will.; Snow, antea, p. 226.—N. M.
sp. Will., **B**, p. 5, 2.—Mex.
sp. Will.. **B**, p. 5, 3.—Mex.

### PARAGUS.

bicolor Fabr.; Snow, antea, p. 227.—Colo., N. M.
dimidiatus Loew; Will., **B**. p. 5.—Mex.
tibialis Fall.; Snow, antea, p. 227.—Colo.

### PIPIZA.

(Pipizella) bellula Will., B, p. 6.—Mex.
pistica Will.; Snow, antea, p. 227.—Colo., N. M.
(Heringia) sp. Will., **B**, p. 6. Mex.

### CHRYSOGASTER.

bellula Will., Synopsis, p. 36, pl. II, figs. 6, 6a; **B**, p. 7; Snow, antea, p. 227.—Mex., N. M., Colo.
nigrovittata Loew; Snow, antea, p. 227.—Colo.
nitida Wied.; Will., **B**, p. 7.—Mex.

### CHILOSIA.

aurotecta G.-T., **G**, p. 4; **I**, p. 58, pl. II, fig. 19.—Mex.
chalybescens Will., Kans. Univ. Quart., ii, 1893, p. 76.—Cal.
chrysochlamys Will., **B**, p. 8, pl. I, figs. 4, 4a.—Mex.
lucta Snow, antea, p. 228.—Colo.
lugubris Will.; Snow, antea, p. 227.—Colo.
petulca Will.; Snow, antea, p. 228.—Colo.
sororcula Will., **B**, p. 9; Snow, antea, p. 228.—Mex., N. M.
sororia Will., **B**, p. 8.—Mex.
tarda Snow, antea, p. 228.—Colo.
sp. Snow, antea, p. 229.—Colo.

### MELANOSTOMA.

bellum G.-T., **G**, p. 3; **I**, p. 38, pl. II, figs. 7, 7a.—Mex.
bucephalus Wied.; Will., **B**, p. 11; F. Lynch A., **D**, pp. 74, 161, (*Syrphus*); G.-T., **I**, p. 34.—Mex., Argentina.
catabombum Will., **B**, p. 12; G.-T., **I**, p. 38.—Mex.
cœrulescens Will.; Snow, antea, p. 229.—Colo.

concinnum Snow, antea, p. 229.—Colo., N. M.
*Melanostoma* n. sp.? Snow, **J**, p. 35.
crenulatum Will., **B**, p. 12, pl. I, figs. 5, 5a, 5b; G.-T., **I**, p. 40.—Mex.
elegans G.-T., **G**, p. 2; **I**, p. 39, pl. 2, fig. 21.—Mex.
kelloggi Snow, antea, p. 230.—Colo.
melanocerum Will., **B**, p. 13.—Costa Rica.
mellinum Linn.; Will., **B**, p. 11; Ent. News. iii, p. 145; F. Lynch A., **D**, pp. 57, 160; G.-T., **I**, p. 37; Snow, antea, p. 230.— Mex., Argentina, Colo.
*Melanostoma* (?) *cruciata* Big. [Will.].
obscurum O. S.; Slosson, **P**.—Mt. Wash.
pruinosum Big.; Will., **B**, p. 11; Ent. News, iii, p. 145.—Mex.
rugonasus Will., **B**, p. 13.—Mex.
stegnum Say.; Will., **B**, p. 10; Ent. News, iii, p. 145; G.-T., **I**, p. 36; Snow, **J**, p. 35; antea, p. 229.—Mex., Colo.
*Melanostoma tigrinum* O. S.; Will., Synopsis, p. 47, pl. II, fig. 7. [Will.].
*Melanostoma fenestratum* Macq., Will., **B**, p. 10. [F. Lynch A., pp. 55, 160].
sp. Will., **C**, p. 255.- Calif.

## PLATYCHIRUS.

chætopodus Will.; Snow, antea, p. 231. -Colo.
hyperboreus Stæg.; Snow, antea, p. 231. Colo.
palmulosus Snow, antea, p. 231. -Colo.
peltatus Meig.; Snow, antea, p. 231.—Colo.

## CATABOMBA.

pyrastri Linn.; F. Lynch A., **D**, p. 78; Snow, antea, p. 232. Colo., N. M.

## EUPEODES.

volucris O. S.; Will., **B**, p. 14; G.-T., **I**, p. 27; Snow, antea, p. 232. -Mex., Colo., N. M.

## SYRPHUS.

americanus Wied.; Will., **B**, p. 15; Snow, antea, p. 236. Colo., Mex., N. M.
arcuatus Fall.; Snow, **J**, p. 36; antea, p. 232.—Colo., N. M.
bisinuatus Will., **B**, p. 17; G.-T., **I**, p. 28.—Mex., Costa Rica.
contumax O. S.; Slosson, **P**.—Mt. Wash.
creper Snow, antea, p. 234.—Colo., N. M.
*Syrphus pauxillus* Snow, (nec Will.), **J**, p. 37.
? *Syrphus lotus* Will., var., Synopsis, p. 75.
decipiens Will., **B**, p. 18.—Mex.
disjectus Will.; Snow, **J**, p. 36; antea, p. 234.—Colo.
disgregus Snow, antea, p. 233.—N. M.
diversus Will., **B**, p. 16, pl. I, figs. 6, 6a.—Mex.

eupeltatus Big.; Will , **B**, p. 16; G.-T., **I**, p. 29.—Mex.
intrudens O. S.; Snow, antea, p. 232.—Colo.
lautus G.-T., **G**, p. 2; **I**, p. 29, pl. II, figs. 4, 4a.—Mex.
lesueurii Macq.; Slosson, **P**.—Mt. Wash.
lotus Will., Synopsis, p. 75; **B**, p. 16.—Mex.
montivagus Snow, antea, p. 236.—Colo.
opinator O. S.; Snow, antea, p. 236.—Colo., N. M.
pullulus Snow, antea, p. 237.—N. M.
ribesii Linn.; Will., **B**, p. 17; F. Lynch A., **D**, p. 71; G.-T., **I**, p. 27; Snow, **J**, p. 37; antea, p. 235.—Mex., Argentina, Colo., N. M.
ruficauda Snow, **J**, p. 36, pl. VII, fig. 3; antea, p. 234.—Colo., N. M.
saussurii G.-T., **I**, p. 30.—Mex.
? *Syrphus* sp. Will., **B**, p. 16, 4. Guatemala.
torvus O. S.; Slosson, **P**.—Mt. Wash.
umbellatarum Schin.; Snow, **J**, p. 37; antea, p. 237.—Colo, N. M.
sp. Snow, antea, p. 235.—N. M.

## DIDEA.

coquilletti Will., **B**, p. 19, pl. I, figs. 9, 9a; G.-T., **I**, p. 21.—Mex.
fuscipes Loew; Snow, antea, p. 238.—N. M.
laxa O. S.; Will., **B**, p. 18; Snow, antea, p. 238; Slosson, **R**.—Mex., N. M., Mt. Wash.

## XANTHOGRAMMA.

habilis Snow, antea, p. 238.—N. M.

## ALLOGRAPTA.

fracta O. S.; Will., **B**, p. 20; G.-T., **I**, p. 41.—Mex.
? *Mesograpta exotica* Wied. (male); F. Lynch A., **D**, p. 161.
*Allograpta* sp. Will., **B**, p. 20. [F. Lynch A., l. c.].
obliqua Say; Will., **B**, p. 19; F. Lynch A., **D**, p. 67; G.-T., **I**, p. 40; Snow, **J**, p. 37; antea, p. 239.—Mex., Argentina, Colo., N. M.
*Syrphus exoticus* Wied. (female). [G.-T ].
*Syrphus quadrigeminus* Thoms. [F. Lynch A.].

## MESOGRAMMA.

basilare Wied.; G.-T., **I**, p. 45.—Mex.
*Mesogramma soror* Schin. [G.-T.].
*Mesograpta basilaris* v. d. Wulp.
*Mesogramma* sp. Will., **B**, p. 25, 4 (male). [G.-T.].
bidentatum G.-T., **I**, p. 49, pl. II, fig. 12.—Mex.
*Mesogramma* sp. Will., **B**, p. 25, 4 (female). [G.-T.].
ciliatum G.-T., **G**, p. 3; **I**, p. 50, pl. II, figs. 16, 16a, 16b.—Mex.
comma G.-T., **G**, p. 4; **I**, p. 53.—Mex.
confusum Schin.; G.-T., **I**, p. 51, pl. II, fig. 11.—Mex.
*Mesograpta* ? *maculipes* Big. [G.-T.].

diversum G.-T., **G**, p. 3; **I**, p. 48, pl. II, fig. 13.—Mex.
duplicatum Wied. (*Syrphus*); G.-T., **I**, p. 44, pl. II, fig. 9.--Mex.
*Syrphus ochrogaster* Thoms [F. Lynch A.].
*Mesograpta duplicata* F. Lynch A., **D**, p. 62.
marginatum Say; Will., **B**, p. 25; G.-T., **I**, p. 52; Snow, **J**, p. 37; antea, p. 229.--Mex., Colo., N. M.
*Mesograpta marginata* Will., Synopsis, p. 100.
*Mesograpta ? circumdata* Big. [Will.].
mutuum Say; Will., **B**. p. 27; G.-T., **I**, p. 43, pl. II, fig. 10.--Mex.
pictum Macq.; G.-T., **I**, p. 52.—Mex.
*Mesogramma pœcilogastra* Loew. [G.-T.].
politum Say; Will., **B**, p. 25; G.-T., **I**, p. 42; Snow, antea, p. 239.—Mex., N. M.
*Mesograpta anchorata* Macq.; F. Lynch A., **D**, p. 61, var. *a*. [G.-T.].
*Mesograpta polita* Will., Synopsis, p. 98; Editors "Insect Life," i, p. 5; ii, p. 113.—N. J.
quinquemaculatum Big., **O**, p. 254 (*Mesograpta*).--Mex.
quinquecinctum Big., **O**, p. 254 (*Mesograpta*).—Mex.
rhombicum G.-T., **G**, p. 3; **I**, p. 46, pl. II, fig. 13.—Mex.
saphiridiceps Big.; Will., **B**, p. 24.—Mex.
subannulatum Loew; G.-T., **I**, p. 47, pl. II, fig. 14.—Mex.
tridentatum Rond.; G.-T., **I**, p. 48, pl. II, fig. 17.—Mex.
*Mesograpta ? pallipes* Big. [G.-T.]
*Mesogramma pallipes* Will., **B**, p. 27.
sp. Will., **B**, p. 26, 5.—Mex.
sp. Will., **B**, p. 26, 6.—Mex.
sp. Will., **B**, p. 27, 8; G.-T., **I**, p. 45.—Mex.

## SPHÆROPHORIA.

cylindrica Say; Snow, **J**, p. 37; antea, p. 239.—Mex., Colo., N. M.
forreri G.-T., **I**, p. 32.—Mex.
*Sphærophoria* sp. Will., **B**, p. 23, 6. [G.-T.].
micrura O. S.; Will., **B**, p. 21; G.-T., **I**, p. 33.—Mex.
nasuta Big., **O**, p. 253 (nec l. c., 1884, p. 103).—Mex.
picticauda Big.; Will., **B**, p. 21; G.-T., **I**, p. 34.—Mex.
syrphica G.-T., **G**, p. 2; **I**, p. 32, pl. II, figs. 5, 5a.—Mex.
trilimbata Big., **O**, p. 253.—Mex.
willistoni G.-T., **I**, p. 31, pl. II, figs. 6, 6a.—Mex.
*Sphærophoria* sp. Will., **B**, p. 22, 5.
sp. Will., **B**, p. 22, 3.—Mex.
sp. Will., **B**, p. 22, 4.—Mex.
sp. G.-T., **I**, p. 33.--Mex.
? *Syrphus calceolatus* Macq. [G.-T.].

## PELECOCERA.

willistoni Snow, **K**, p. 187; antea, p. 239.—N. M.

### SALPINGOGASTER.

limbipennis Will., **B**, p. 29.—Mex.
nigra Schin.; Will., **B**, p. 29.—Guatemala, Panama.
*Salpingogaster anchoratus* Big. [Will.].
nova G.-T., **F**, p. 7; **I**, p. 23, pl. II, fig. 3.—Mex.
pygophora Schin.; Will., **B**, p. 29.—Panama.

### BACCHA.

adspersa Fabr.; Will., **B**, p. 34; F. Lynch A., **D**, p. 157.—Pan'a, S. A.
ænea Will., **B**, p. 37, pl. I, figs. 10, 10a.—Mex.
attenuata Will., **B**, p. 35.—Mex.
clavata Fabr.; Will., **B**, p. 33; Ent. News, iii, p. 145; F. Lynch A., **D**. pp. 47, 159; G.-T., **I**, p. 57; Snow, antea, p. 239.—Mex., Argentina, N. M.
*Baccha babista* Walk.; Will., Synopsis, p. 117, pl. IV, fig. 9. [Will.].
*Baccha facialis* Thoms. [Will.].
cœrulea Will., **B**, p. 38.—Mex.
concinna Will., **B**, p. 38.—Mex.
conjuncta Wied.; Will., **B**, p. 33.—Mex.
dolosa Will., **B**, p. 37, pl. I, figs. 7, 7a, 7b.—Mex., Guatemala.
gracilis Will., **B**, p. 34.—Mex.
laudabilis Will., **B**, p. 36.—Mex.
lemur O. S.; Snow, antea, p. 240.—Colo., N. M.
lepida Macq.; G.-T., **I**, p. 55.—Mex.
livida Schin.; Will., **B**, p. 33.—Mex.
luctuosa Big.; Will., **B**, p. 39.—Costa Rica.
lugubris Will., **B**, p. 37.—Mex.
marmorata Big.; G.-T., **I**, p. 58, pl. II, fig. 19.—Mex.
nasuta Big., **N**, p. 103 (*Sphærophoria*); Will.,* **B**, p. 35; G.-T., **I**, p. 57, pl. II, fig. 8.—Mex.
obscuricornis Loew; Snow, antea, p. 240.—N. M.
phæoptera Schin.; Will., **B**, p. 33.—Mex., Guatemala.
punctifrons Will., **B**, p. 36.—Mex.
rubida Will., **B**, p. 34, pl. I, figs. 8, 8a, 8b.—Mex.
sagittifera Austen, **M**, p. 144, pl. IV, fig. 14.—Jamaica.
spatulata G.-T., **G**, p. 4; **I**, p. 56, pl. II, figs. 18, 18a.—Mex.
stenogaster Will., **A**, p. 266; **B**, p. 34.—Mex.

### OCYPTAMUS.

dimidiatus Fabr.; Will., **B**, p. 30; G.-T., **I**, p. 53.—Mex.
*Baccha dimidiata* Will., Synopsis, p. 120, pl. V. fig. 10.—San Dom.
fenestratus Big.; G.-T., **I**, p. 53.—Mex.

*Curiously enough, Dr. Williston gave this species which he thought to be new, the same specific name applied earlier to the species by Bigot.

funebris Macq.; Will., **B**, p. 30; F. Lynch A., **D**, pp. 50, 159; G.-T., **I**, p. 54.—Mex , Argentina.
  *Baccha funebris* Will., Synopsis, p. 125.
iris Austen, **M**, p. 133, pl. IV, fig. 1.—Jamaica.
trigonus Wied.; Will., **B**, p. 30; Ent. News, iii, p. 146; F. Lynch A., **D**, pp. 51, 159; G.-T., **I**, p. 54.—Mex., Argentina.
  *Baccha torva* Will , Synopsis, p. 124. [Will.].
  *Syrphus gastrostactus* Will., (nec Wied.) **A**, p. 264.—Brazil.
  *Syrphus* sp. Will., **B**, p. 17, 8.—Mex. [Will.].

### MYIOLEPTA.

auricaudata Will., **B**, p. 40, pl. I, figs. 11, 11a, 11b.—Mex.

### RHINGIA.

nasica Say; Snow, **J**, p. 37; antea, p. 240.—Colo.
nigra Macq.; Will., **B**, p. 40.—Mex.

### PHALACROMYIA.

bellula Will., **B**, p. 42.—Mex.
pica Schin.; Will., **B**, p. 41.—Mex.
pulchra Will., **B**, p. 41.— Costa Rica.
vaga Wied.; Will., **B**, p. 42; G -T., **H**, p. 56 (*Volucella*).—Mex.
  *Volucella viridula* Big. [G.-T ].
virescens Will., **B**, p. 42.- Guatemala.

### VOLUCELLA.

amethystina Big.; Will., **B**, p. 52.—Mex.
anna Will.; Snow, antea, p. 240.—N. M.
apicifera Towns., MS.; Snow, antea, p. 241.—N. M.
ardua Wied.; G.-T., **H**, p. 56. Mex.
avida O.-S.; Will., **B**, p. 47; G.-T., **H**, p. 53; Snow, antea, p. 241.—Mex., N. M.
brevis G.-T., **F**, p. 4; **H**, p. 63.—Mex.
cæsariata Will., **B**, p. 49; G.-T., **H**, p. 60.—Mex.
  *Volucella hirsuta* G.-T., **F**, p 3. [G.-T.].
chætophora Will., Synopsis, p. 149; **B**, p. 52, pl. I, figs. 15, 15a, 15b.—Mex.
chalybescens Wied.; G.-T., **H**, p. 52.—Mex.
comastes Will., **B**, p. 52; ? G.-T., **H**, p. 51.—Mex.
comstocki Will., Synopsis, p. 138, pl. VI, fig. 9; **B**, p. 51; Snow, antea, p. 240.— Mex., N. M.
craverii G.-T., **F**, p. 2; **H**, p. 49.—Mex.
dichroica G.-T., **F**, p. 3; **H**, p. 55.—Mex.
esuriens Fabr.; Will., **B**, p. 50; G.-T., **H**, p. 47; Snow, antea, p. 240.—M-x., Guatemala, N. M.
  *Volucella transatlantica* Rond. [G.-T.].
  *Volucella esuriens mexicana* Will., Synopsis, p. 137, pl. VI, figs. 5, 5a.

evecta Walk.; Slosson, **R**.—Mt. Wash.

facialis Will.; Snow, antea, p. 240.—Colo.

fasciata Macq.; Will., **B**, p. 48; Snow, antea. p. 241.—Mex., Colo.

flavissima G.-T., **F**, p. 3; **H**, p. 50.—Mex.

fraudulenta Will., **B**, p. 48, pl. I, figs. 13, 13a, 13b; G.-T., **H**, p. 59. —Mex.

furens G.-T., **F**, p. 2; **H**, p. 48.—Mex.

fuscipennis Macq.; Will., **B**, p. 54.—Mex.

haagii Jænn; Will., **B**, p. 51; G.-T., **H**, p. 50; Snow, antea, p. 241. Mex., N. M.

hyaloptera G. T., **F**, p. 3; **H**, p. 57.—Mex.

hystrix G.-T., **F**, p. 4; **H**, p. 62.—Mex.

isabellina Will., Synopsis, p. 140; **B**, p. 46; Snow, antea, p. 241. —N. M., Mex.

lata Wied.; G.-T., **H**, p. 46 (*Camerania*) (nec Will., **B**, p. 45). —Mex.

lugens Wied.; Will., **B**, p. 54.—Guatemala.

macrocephala G.-T., **H**, p. 45, pl. I, fig. 13 (*Camerania*).—Mex.

*Volucella* (*Temnocera*) *megacephala* Will., Synopsis, p. 146 (nec Loew).

*Volucella lata* Will. (nec Wied ), **B**, p. 45. [G.-T.].

macula Wied.; Will., **B**, p. 51.—Mex.

mellea Jænn.; Will., **B**, p. 49; G.-T., **H**, p. 58.—Mex.

minima G.-T., **F**, p. 3; **H**, p. 53.—Mex.

obesa Fabr.; Will., **B**, p. 50; F. Lynch A.,**D**, p. 128; Roeder, **L**, p. 341; G.-T., **H**, p. 64; Snow, antea, p. 241.—Guatemala, Costa Rica, Panama, N. M.

*Volucella violacea* Macq. (nec Say). [G.-T.].

obesoides G.-T., **F**, p. 4; **H**, p. 65.—Mex.

omochroma G.-T., **F**, p. 2; **H**, p. 47.—Mex.

opinator Will., **B**, p. 51, pl. I, figs. 14, 14a, 14b.—Mex.

ornata Will., **B**, p. 49; G.-T., **H**, p. 61.—Mex.

*Volucella hispida* G.-T., **F**, p. 4. [G.-T.].

pallens Wied.; Will., **B**, p. 53; Ent. News, iii, p. 146; G.-T., **H**, p. 57.—Guatemala.

*Volucella sexpunctata* Loew; Will., Synopsis. p. 141, pl. VI, fig. 2. [Will.].

? *Volucella testacea* Rond. [G.-T.].

*Volucella punctifera* Big. [G.-T.].

picta Wied.; Will., **B**, p. 47.—Mex., Cuba.

*Volucella pulchripes* Big. [Will.].

postica Say, G.-T., **H**, p. 49.—Mex.

*Volucella castanea* Big.: Will., **B**, p. 45. [G.-T.].

purpurifera Big.; Will.; **B**, p. 54.—Mex.

quadrata Will., **B**, p. 46, pl. I, figs. 12, 12a, 12b.—Mex.

satur O. S.; Snow, antea, p. 241.—Colo., N. M.

tau Big.; Snow, antea, p. 241.—Colo., N. M.
trigona G.-T., **F**, p. 3; **H**, p. 52.—Mex.
tristis Big.; G.-T., **H**, p. 54.—Mex.
*Phalacromyia melanorhina* Big. [G.-T.].
tympanitis Fabr.; Will., **B**, p. 52.—Mex., Panama.
volucris G.-T., **F**, p. 4; **H**, p. 61.—Mex.
sp. Will., **B**, p. 48, 8.—Mex.
sp. Will., **B**, p. 53, 23.—Guatemala.
sp. Will., **B**, p. 53, 24.—Panama.
sp. G.-T., **H**, p. 63.—Mex.

### BRACHYOPA.

vacua O. S.; Snow; antea, p. 240.—Colo.
cynops Snow, **J**, p. 37, pl. VII, fig. 2; antea, p. 240.—Colo.

### MEGAMETOPON.

nasicum Will.; G.-T., **H**, p. 44, pl. I, figs 12, 12a, 12b.—Mex.
*Ophromyia nasica* Will., **B**, p. 55, pl. II, figs. 1, 1a, 1b.

### COPESTYLUM.

limbipenne Will., **B**, p. 56, pl. II, figs. 2, 2a, 2b.—Mex.
*Copestylum limbipennis* Will., Synopsis, p. 152.
marginatum Say.; Will., **B**, p. 56; G.-T., **H**, p. 40, pl. I, fig. 14; Snow, **J**, p. 37; antea, p. 241.—Mex., Guatemala, Colo., N. M.
? *Copestylum distinctum* G.-T., **H**, p. 41, pl. I, fig. 15.
? *Copestylum simile* G.-T., **F**, p. 2; **H**, p. 42.
? *Copestylum parvum* G.-T., **F**, p. 2; **H**, p. 42.

### SERICOMYIA.

militaris Walk.; Snow, **J**, p. 37; antea, p. 242.—Colo., N. M.

### ARCTOPHILA.

flagrans O. S.; Snow, antea, p. 242.—Colo., N. M.

### ERISTALIS.

æmulus Will., **B**, p. 64, pl. II, fig. 5; G.-T., **I**, p. 13.—Mex., Guatemala, Panama.
agrorum Fabr.; F. Lynch A., **D**, p. 118.—Argentina.
albifrons Wied.; Will., **B**, p. 62; Ent. News, iii, p. 146.—Mex.
*Eristalis albiceps* Macq.; Will., Synopsis, p. 172. [Will.].
atropos G.-T., **G**, p. 1; **I**, p. 14, pl. II, fig. 23.—Mex.
bogotensis Macq.; F. Lynch A., **D**, p. 109; G.-T., **I**, p. 4.—Argentina, Mex.
? *Eristalis everes* Walk. [G.-T.].
*Eristalis bellardi* Jænn; Will., **B**, p. 60. [Will.].
*Eristalis rufoscutata* Big. [Will.].

brousi Will.; Snow, **J**, p. 38; antea, p. 243.—Colo.
circe Will., **B**, p. 59, pl. II, figs. 3, 3a; G.-T., **I**, p. 3.—Mex.
*Eristalis bombusoides* G.-T., **F**, p. 4. [Will.].
clarissimus G.-T., **F**, p. 5; **I**, p. 11.—Mex.
compactus Walk.; Slosson, **P**.—Mt. Wash.
cosmius Schin.; Will., **B**, p. 61.—Mex.
dimidiatus Wied.; Slosson, **P**.—Mt. Wash.
fasciatus Wied.; Will., **B**, p. 62.—Mex., Guatemala.
*Eristalis podagra* Macq., Will., **A**, p. 281.—Brazil. [Will.].
*Eristalis bifasciatus* Macq. [Will.].
flavipes Walk.; Snow, antea, p. 243.—Colo.
furcatus Wied.; Will., **B**, p. 61; F. Lynch A., **D**, p. 111; G.-T., **I**, p. 15.—Mex., Argentina.
*Eristalis femoratus* Macq. [Will.].
hirtus Loew.; Snow, antea, p. 242.—Colo., N. M.
lateralis Walk.; F. Lynch A., **D**, p. 111.—Argentina.
latifrons Loew; Will., **B**, p. 60; G.-T., **I**, p. 5; Snow, **J**, p. 38; antea, p. 242.—Mex., Colo., N. M.
mexicanus Macq.; G.-T., **I**, p. 5.—Mex.
minutalis Will., **B**. p. 64, pl. II, figs. 6, 6a.—Mex.
obsoletus Wied.; Will., **B**, p. 59; Ent. News, iii, p. 146; F. Lynch A, **D**, pp. 121, 164; G.-T., **I**, p. 7.—Mex., Argentina.
*Eristalis testaceicornis* Macq. [Will.].
*Eristalis thoracica* Jænn. [Will.].
*Eristalis pachypoda* Big.; Will, **B**, p. 60. [G.-T.].
ochraceus Will., **A**, p. 279; **B**, p. 60.—Brazil, Mex.
persa Will, **B**, p. 58.—Mex.
pusillus Macq.; G.-T, **I**, p. 10.—Mex.
*Eristalis tricolor* Jænn.; Will., **B**, p. 62. [G-T.].
ruficeps Macq.; G.-T., **I**, p. 6.—Mex.
rufiventris Macq.; Will., **B**, p. 65; G.-T., **I**, p. 11.—Mex.
*Eristalis præclarus* G.-T, **F**, p. 5. [G.-T.].
sallei G.-T., **F**, p. 5; **I**, p. 12.—Mex.
scutellaris Fabr.; Will., **B**, p. 63; Ent. News, iii, p. 146; **I**, p. 12.—Mex.
*Palpada scutellata* Macq.
*Priomerus scutellata* Big.
*Priomerus bimaculatus* (Macq.) Big. [Will.].
*Eristalis cognatus* Rond. [G.-T.].
*Eristalis agnatus* (ol. *cognatus*) Rond. [G.-T.].
*Eristalis fascithorax* Macq. [Schin.].
*Eristalis cyaneifer* Walk. [G.-T.]
*Doliosyrphus scutellatus* Big.
*Doliosyrphus rileyi* Will. [Will.].
*Priomerus scutellaris* F. Lynch A., **D**, pp. 101, 162.
sumichrasti G.-T, **G**, p. 1; **I**, p. 6.—Mex.

tenax Linn.; Snow, antea, p. 242; Slosson, **P**.—Colo., Mt. Wash.
transversus Wied.; Snow., antea, p. 243.—Colo.
triangularis G.-T., **F**, p. 6; **I**, p. 9.—Mex.
*Eristalis* sp. Will., **A**, p. 281; **B**, p. 63, 14.
trilimbatus G.-T., **F**, p. 5; **I**, p. 8.—Mex.
trigonus Will., **B**, p. 61, pl. II, figs. 4, 4a.—Mex.
vinetorum Fabr.; Will., **B**, p. 63; Ent. News, iii, p. 146; F. Lynch A., **D**, p. 116; Roeder, **L**, p. 341; G.-T., **I**, p. 7.—Mex., Guatemala, Argentina.
sp. Will., **B**, p. 64, 18.—Mex.
sp. Will., **B**, p. 65, 21.—Mex.
sp. G.-T., **I**, p. 10.—Mex,

## MEROMACRUS.

zonatus Loew; Will., **B**, p. 67 (*Pteroptila*); G.-T., **I**, p. 16 (*Pteroptila*). —Mex.
cruciger Wied.; Will., **B**, p. 66 (*Pteroptila*).—Mex.

## LYCASTRIRHYNCA.

nitens Big.; Will., **B**, p. 66; G.-T., **I**, p. 17; Austen, **M**.—Mex., S. A.

## HELOPHILUS.

lætus Loew; Snow, antea, p. 243.—Colo.
latifrons Loew; Will., **B**, p. 68; Snow, **J**, p. 38; antea, p. 243. —Mex., N. M., Colo.
similis Macq.; Snow, antea, p. 243.—Colo.
trivittatus Fabr.; G.-T., **I**, p. 18.—Mex.
sp. Snow, antea, p. 243.—Colo.

## ASEMOSYRPHUS.

bicolor Big.; G.-T., **I**, p. 19.—Mex.
*Helophilus mexicanus* Will., **B**, p. 68, pt. (nec Macq.). [G.-T.].
*Asemosyrphus olivaceous* G.-T., **F**, p. 6. [G.-T.].
*Asemosyrphus impurus* G.-T., **F**, p. 6. [G.-T.].
mexicanus Macq.; Will., Synopsis, p. 186, pl. VIII, fig. 7; **B**, p. 68, pt. (*Helophilus*); G.-T., **I**, p. 20.—Mex.
*Asemosyrphus nigroscutatus* Big. [Will.].
*Asemosyrphus flavocaudatus* Big. [Will.].
*Asemosyrphus griseus* G.-T., **F**, p. 6. [G.-T.].

## PLATYNOCHÆTUS.

niger G.-T., **F**, p. 6; **I**, p. 20, pl. II, figs. 1, 1a.—Mex.

## MALLOTA.

albipilis Snow, antea, p. 244.—N. M.
? championi Will., **B**, p. 69.—Mex.

margarita Will., **B**, p. 70, pl. II, figs. 7, 7a, 7b.—Mex.
posticata Fabr.; Slosson, **R**.—Mt. Wash.
sackeni Will; id. **B**, p. 70.—Mex.
smithi Will., **B**, p. 70, pl. II, figs. 8, 8a, 8b.—Mex.

### TROPIDIA.

incana Towns., MS.; Snow, antea, p. 244.—Colo.

### CRIORHINA.

coquilletti Will., Ent. News, iii, p. 145.—Calif.
johnsoni Coq., Ent. News, v, 1894, p. 125.—Wash.
umbratilis Will.; Snow, **J**, p. 38.—Kans.

### CRIOPRORA.

arctophiloides G.-T., **F**, p. 7; **I**, p. 25, pl. II, figs. 2, 2a.—Mex.

### XYLOTA.

analis Will.; Snow, antea, p. 244.—N. M.
brachygaster Will., **B**, p. 72.—Mex.
communis Walk.; G.-T., **I**, p. 26.—Mex.
curvipes Loew; Slosson, **P**.—Mt. Wash.
ejuncida Say; Snow, antea, p. 245.—Colo., N. M.
favitibia Big.; Snow, **J**, p. 38; antea, p. 244.—Colo., N. M.
pauxilla Will., **B**, p. 71, pl. II, figs. 9, 9a, 9b.—Mex.
rufipes Will., **B**, p. 71.—Mex.
stenogaster Will., **B**, p. 72.—Mex., Guatemala.

### SYRITTA.

pipiens Linn.; Snow, **J**, p. 38; antea, p. 245.—Colo., N. M.
vagans Wied.; Will., **B**, p. 73.—Mex., Costa Rica.
*Syritta americana* Schin.; Will., **A**, p. 285. [Will.].
*Syritta mexicana* Big. [Will.].

### CERIOGASTER.

auricaudata Will., **B**, p. 73, pl. II, figs. 10, 10a.—Mex.

### CHRYSOCHLAMYS.

crœsus O. S.; Snow, antea, p. 245.—Colo., N. M.

### SPILOMYIA.

kahli Snow, antea, p. 245.—N. M.
liturata Will.; Snow, antea, p. 245.—N. M.
quadrifasciata Say; Snow, antea, p. 245.—Kans.
sp. G.-T., **I**, p. 24.—Mex.

### TEMNOSTOMA.

alternans Loew; Slosson, **P.**—Mt. Wash.
bombylans Fabr.; Slosson, **P.**—Mt. Wash.
venustum Will.; Slosson, **R.**—Mt. Wash.

### MILESIA.

pulchra Will., **B**, p. 74, pl. II, figs. 11, 11a, 11b, 11c.—Guatemala.

### CERIA.

abbreviata Loew; Snow, antea, p. 246.—Colo.
arietis Loew; G.-T., **H**, p. 32.—Mex.
bergrothi Will., **B**, p. 77.—Mex.
meadei Will., **B**. p. 76, pl. II, figs. 12, 12a, 12b.—Mex.
nigra Big.; Will., **B**, p. 77.—Mex.
pedicellata Will., Synopsis, p. 264; **B**, p. 77.—Mex.
signifera Loew; G.-T, **H**, p. 32.—Mex.
schnablei Will., **B**, p. 76.—Mex.
townsendi Snow, antea, p. 246.—N. M.
tridens Loew; Snow, antea, p. 246.—N. M.
verralli Will., **B**, p. 75.—Panama.

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# Dialysis and Triptotricha.

BY S. W. WILLISTON.

In the Insecta Saundersiana, p. 4, Walker described a genus of diptera under the name of *Dialysis*, referring it to the Xylophagidæ. He based the genus upon a specimen which he had previously referred doubtfully to *Xylophagus americanus* Wied.* From the description, Loew was in doubt† as to the location in the Xylophagidæ. In 1879, Bigot recognized the genus and described a species (*D. dispar*) of it from California.‡ Later Osten Sacken examined Walker's type specimen and referred it to the genus *Triptotricha*,§ but did not accept Walker's name, contending that the genus had never been recognizably described. Rather reluctantly I accepted this rejection of the name in my Synopsis of the genera of Leptidæ,|| though the synonymy was recognized.

In 1889 Bergroth described** a new species of the genus from the United States, under the name *Dialysis disparilis*, led thereto by his well-known views regarding the rigidity of zoological nomenclature. He urged that Bigot had been able to recognize the genus, though he had erred in locating it among the Xylophagidæ.

Until recently all the species known to me have two spurs on the front tibiæ, and I have so defined *Triptotricha* in the generic synopses given by me, overlooking the fact, to which my attention has recently been called by Prof. Aldrich, that the genus *Triptotricha* Loew was said by its author to have *one* tibial spur†† ("Die von mir erichtete Gattung Triptotricha gehört, wegen der Anwesenheit eines starken Sporns an den Vorderschienen," etc.). In his original diagnosis of the genus‡‡ he makes no mention of this character, and it so happens that the type species of the genus has *two* anterior tibial spurs, as has been shown by Townsend.§§ This last mentioned author also shows that one of the species placed by Loew in the genus (*T. rufithorax* Say) has but the one spur.

*List, etc., I, 128.
†Monog., I, 16.
‡An. Soc. Ent. Fr. 1879.
§Berl. Ent. Zeit., XXVII, 295.
||Entom. Amer., April, 1885.
**Wien. Ent. Zeit., p. 296.
††Berl. Ent. Zeit., XVIII, 380, 1874.
‡‡Centur., X, 15.
§§Proc. Wash. Ent. Soc., II, 118.

In Entom. Amer., II, p. 106, I described a new genus of Leptidæ under the name *Agnotomyia*, based upon the presence of but four posterior cells in the wing and of but one anterior tibial spur. The species upon which the genus was founded was the long-lost *Lomatia elongata* of Wiedemann, which had previously been placed among the Bombyliidæ. Another species agreeing in these characters was known to me at the time, but I did not describe it. With the knowledge of the fact that *T. rufithorax* has but a single spur, and the vein of the wing separating the fourth and fifth posterior cells often incomplete, Townsend rightly came to the conclusion that the two genera were less certainly distinct than had seemed to be the case.

Within the past few months, Prof. Aldrich has very kindly submitted to me another species with a single spur and with five posterior cells. Wishing to ascertain further in regard to the type of *Dialysis*, I wrote to Mr. Austen of the British Museum for information especially concerning this character. Mr. Austen, with great kindness, has written me the following in reply: "There is only *one* spur on the front tibiæ of the type specimen of Walker's *Dialysis dissimilis*. I am astonished to find, however, that there are *only four posterior cells* in the wing, as seen in the accompanying drawing.

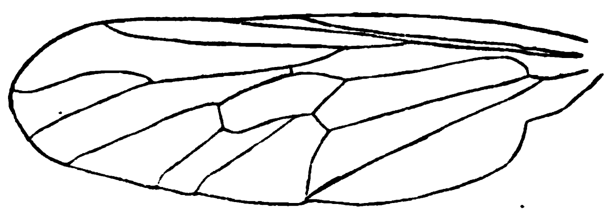


Fig 1.

This extraordinary venation seems to have escaped the notice of Baron Osten Sacken, when he examined the specimen. The two wings are exactly alike and there is no stump or other trace of the missing vein in either of them. In other respects the specimen is a Leptid and agrees generally with the description of *Triptotricha fasciventris* Loew. The abdomen agrees absolutely with Loew's description. In other respects there are the following differences: Third joint of the antennæ and the arista blackish; I cannot detect any trace of black hairs on the first two joints; thorax with a reddish brown median stripe, extending to the base of the scutellum, but not quite reaching the anterior margin: humeri shimmering whitish when viewed from above; front and middle tarsi uniformly brown, first joint not paler; first and second joints of hind tarsi yellowish, but brown at the tips.

Length of the body 10 millim.; of the wings 8⅓ millim. One specimen."

It is very fortunate for Dipterology that so able a student as Mr. Austen is engaged in the study of the British Museum diptera. We can now confidently expect to learn much that will be of value concerning Mr. Walker's unrecognizable species and genera.

This much results from the above facts: The genus *Agnotomyia* is absolutely identical with *Dialysis* and must be abandoned. Is the presence of but four posterior cells a good generic character? I can not say. Genera are founded in allied families on the same or similar grounds, and I have yet to see a specimen of *Dialysis* (in the sense of *Agnotomyia*) in which the character is variable. Still, from the fact that there are other species with the same tibial character and four posterior cells, and especially because there seems to be a tendency to variation in the venation of *Triptotricha*, I am inclined to give up this character, and base the genus for the present on the tibial character alone. With this conclusion, both *Dialysis* and *Triptotricha* may be retained. If *Dialysis* is maintained upon the wing character, then I believe it would be justifiable to place *D. rufithorax* and the following new species in a new genus.

The following species belong to the genus *Triptotricha:*

**T. disparilis** Bergroth. Wien. Ent. Zeit., 1889, 296; and 1892, 162.

**T. lauta** Loew, Centur., X, 15.

The following in *Dialysis:*

**D. dissimilis** Walker, Ins. Saund., 4.

**D. rufithorax** Say. J. Acad Phil., III. 36; Compl. Wr., II, 56.

**D. elongata** Say, Journ. Acad. Phil., III, 41: Compl. Wr., II, 58 (*Stygia*); *Anthrax, Lomatia* Wiedemann; *Agnotomyia* Williston.

**D. aldrichi** Williston, nov., infra.

The following species are indeterminable at present:

**D. dispar** Bigot, Ann. Soc. Ent. Fr., 1889.

**T. discolor** Loew. Berl. Ent. Zeit, 1874, 379.

**T. fasciventris** Loew, l. c., 380.

**Dialysis aldrichi** n. sp.

Male. Eyes separated by linear space, which, with the vertical triangle, is black; frontal triangle with yellow pubescence. First joint of the antennæ blackish; second joint reddish yellow; third joint and the arista black; first two joints with black hair. Proboscis yellowish pile; humeri yellowish dusted. Pleuræ shining black, the upper part of the meso- and metasternum white. Halteres yellow, the knob blackish. First four segments of the abdomen yellow with a black anterior cross-band, expanded triangularly in the middle to, or nearly to, the hind margin; remaining segments black with the

hind angles yellow. Legs yellow, all the tarsi and the tip of all the tibiæ black; hind tibiæ brownish; tip of hind femora brown or blackish; coxæ in part yellow. Wings tinged with blackish, the immediate base, the costal cell and the outer part of the subcostal and marginal cells yellow; fourth posterior cell usually short-petiolate at the base. Length 9–10 millim.

Four specimens, Craig mountains, Idaho, J. M. Aldrich.

# New Bombyliidæ.

BY S. W. WILLISTON.

The two following genera of Bombyliidæ, of considerable interest, I have been unable to identify with any forms previously described:

**Desmatoneura**, gen. nov.

Origin of the second vein from the third at a distance from the anterior cross-vein nearly equal to twice the length of that vein, and beyond the proximal end of the discal cell; its originis rectangular, with the anterior angle rounded; four posterior cells present, all open; anal cell open. Eyes of male separated at vertex by a space about equal in width to the length of the antennæ; front large. Antennæ small, remote from each other at their root, the first two joints very small, the third with a small bulbous base and an elongated, styliform projection about twice the length of the basal portion, terminating in a very minute bristle and without suture. Face retreating. Proboscis small, concealed within the oral cavity. Mesonotum with a few small bristles on the post-alar callosities and on the sides of the scutellum. Abdomen slender, cylindrical, gradually tapering; hypopygium small and mostly concealed. All the tibiæ with small bristles; pulvilli distinct. The marginal cell is moderately expanded at the extremity.

The genus is most nearly related to *Aphoebantus*, which it much resembles, but will be at once distinguished by the origin of the second vein and by the front.

**Desmatoneura argentifrons**, n. sp.

Male. Front completely covered with a dense, brilliant, yellowish silvery tomentum or dust and with some fine, yellowish white pile, visible from the side; in perpendicular view there is seen a triangular yellow spot in the ground-color, reaching between the margins of the eyes where they begin to diverge. Face with a white dust, only partially concealing the black ground-color, and with short white pile. Antennæ black. Mesonotum and scutellum brownish black, opaque, with sparse yellowish tomentum; hair of the pleuræ white. Knob of the halteres light vitelline yellow. Abdomen covered with uniform yellowish tomentum and with white pile on the sides and venter. Legs black, the knees yellow; femora and tibiæ largely or

mostly concealed beneath white tomentum. Wings hyaline, the costal cell yellowish brown; broadly across the middle of the wing brownish; the distal part cinereous. Length 8 mm.

One specimen, Albuquerque, N. M., F. H. Snow, August, 1894.

**Desmatomyia**, gen. nov.

Head as broad as the thorax, transverse. Front broad, only a little narrowed above, with a longitudinal groove in the middle. Antennæ elongate, stout; first joint longer than broad; second joint a little broader than long; third joint flattened, elongated, gradually tapering; style large, flattened, composed of two distinct joints, the first a little broader than long and with distinct constrictions distally and proximally; second joint ovate, more than twice as long as wide, a little wider in the middle than the first joint, obtusely pointed and without bristle or hairs; altogether the length of the antennæ is about twice that of the head. Face retreating, very short; oral opening moderately large; cheeks nearly horizontal transversely, together equal to a little less than one-half the distance between the eyes below. Proboscis small, with the palpi wholly concealed within the oral cavity. Thorax short, convex, almost wholly bare (a few very short bristles are seen above the root of the wings); scutellum oval, with a few hairs. Abdomen short and broad, nearly as broad as long, wholly bare; genitalia concealed. Legs moderately stout, almost wholly bare, the femora and the four posterior tibiæ with short spinules. Neuration resembling that of some species of *Geron*, save that there are four posterior cells; the second vein takes its origin acutely, opposite the proximal end of the discal cell; first posterior cell broadly open; second posterior cell sessile, that is, the vein back of it springs from the fourth vein at the angle of the discal cell; discal cell small, the penultimate section of the fifth vein (the vein bordering the discal cell posteriorly) nearly as long as the ultimate section; anal cell narrowly open; marginal cell not at all expanded at the extremity; two submarginal cells, the outer one narrow and long. Tegulæ small. Pulvilli padlike; no empodia.

**Desmatomyia anomala**, n. sp.

Black. Front, face and cheeks thinly whitish pollinose, opaque. Mesonotum with shining stripes between the grayish pollen. Scutellum opaque grayish. Pleuræ thickly gray pollinose. Halteres light yellow. Abdomen shining black; each of the segments with a narrow, light yellow hind margin, the last one occupying nearly the whole segment. Legs reddish yellow; femora, except the tip, black, the tarsi brown or brownish. Wings cinereous hyaline. Length 4 mm.

One specimen, Univ. of Kans. coll. The single specimen of this singular fly was captured by Mr. E. S. Tucker, of the University of Kansas, in the Garden of the Gods, Colo. I am indebted to Mr. W. A. Snow for calling my attention to it. With myself, Mr. Snow was puzzled where to locate the fly, from the peculiar structure of the antennæ, but, after study, it seems to both of us that it should be placed among the Bombyliidæ. In general appearance the fly resembles *Geron* or *Phthiria*.

# The Stratigraphy of the Kansas Coal Measures.*

BY ERASMUS HAWORTH.

**OUTLINES OF STRATIGRAPHY:**

Ratio of Limestone to Shales and Sandstone.
Characteristics of the Limestone.
Characteristics of the Shales and Sandstone.
Extent of Marginal Areas.
Inclination of Strata, Faults and Fissures.
Shales Principally Sub-Marine in Origin.
General Conditions of Deposition.

One of the first conceptions regarding the stratigraphy of the Kansas Coal Measures is that in general all formations both dip and thicken to the westward, and that occasionally a wedge-shaped formation which may be quite heavy underground at one place fails to reach the surface to the east on account of its thinning out in that direction until it entirely disappears. The second point of general importance is that while the Coal Measures consist of limestones, sandstones, and shales, the limestones are by far the most regular and persistent laterally and therefore are the most important stratigraphically, although they never nearly equal the others in thickness. There are great shale beds, it is true, which are remarkably persistent and tolerably regular. If we look upon them as the principal formations with occasionally included sandstones, into which they may grade and again change back into shales, we can also use them very well in doing stratigraphic work. In this way we would consider but two formations, the limestones and the shales. It is believed that the student, who, with report in hand, may pass over the ground to correct or verify the conclusions here reached will find it to his advantage actually to think of the formations in this way.

## OUTLINES OF STRATIGRAPHY.

Beginning at the base of the Coal Measures we will now mention in ascending order each formation of any considerable thickness up to the Cottonwood Falls limestone, and add such remarks of a general character as may be deemed advisable in order to give a clear and

*The University Geological Survey has about completed its work on the stratigraphy of the Coal Measure area lying south of the Kansas river, a report on which will soon appear as Volume I of the Survey. From it the following summaries are condensed.

connected description of the location and extent of each of them. Plate XX is a generalized section of the Coal Measures from the Mississippian up to and including the Cottonwood Falls limestone. This is known to be near the base of the Permian, but this Survey has not attempted to locate the division line exactly. The Cottonwood Falls limestone is simply taken because it is a prominent system and therefore a good division line between the two seasons' work. The total thickness here given is 2750 feet, 800 feet of which is Lower Coal Measures and 1950 feet Upper Coal Measures. In making this estimate the maximum thickness of the different formations was never used, neither was the minimum. It is doubtful if at any one place a drill would prove the distance to the Mississippian to quite equal the figures given, but there certainly could not be much of a decrease in the thickest portions.

At the base of the Coal Measures lie the Cherokee shales, with a thickness averaging about 450 feet. In the vicinity of Paola they seem to be over 700 feet thick, but in other places they are not more than 400, while at Fredonia they are only about 350. This shale bed with its included sandstone is the most remarkable formation in some respects in the whole Coal Measures. It has great lateral extent. Its northwestern extension is unknown. At Cherryvale it is nearly 425 feet thick: at Neodesha it is fully 425 feet; at Thayer it is known to be 400 feet, but how much more cannot be said. At Chanute it is 410 feet, and at Humboldt the deep well passed 325 feet into it, but did not pass through it. To the north it reaches in undiminished thickness to Leavenworth with the following thicknesses at various intervening places, as shown by deep wells at the places named: Girard, 446; Fort Scott, 410; Pleasanton, 440; Paola, 750; Kansas City, 420; and Leavenworth, 540. There are many reasons for believing that the same shale beds reach entirely across the state of Missouri and into Iowa. Broadhead* mentions a few deep borings, one in Ray county, which shows them to be about 400 feet, and in his general section of the Missouri Coal Measures he gives from 350 to 450 feet of shales and sandstone at the base. Records of a number of other wells in northern Missouri show the same condition. From the accounts of the Iowa Coal Measures given in the different geological reports of that state, and from the writer's personal knowledge of portions of the state, it is reasonably certain that nearly the whole of the Iowa Coal Measures have a heavy shale bed at their base which connects directly with the similar one in Missouri, and that in turn with the Cherokee shales in Kansas. Southward into the Indian Territory the same shale bed extends for many miles, and

* Mo. Geol. Survey Rep., 1872, p. 83.

probably they connect with the heavy shale beds at the base of the Coal Measures in Arkansas and Texas, making one continuous formation from 600 to 700 miles in extent.

The Cherokee shales are therefore of much more than local importance. This is true not only from the standpoint of stratigraphy, but also on account of their great economic importance. Wherever they are known they carry relatively large bodies of coal, and in Kansas and Missouri they and the included sandstone are the main oil and gas producers.

Wherever the Cherokee shales are known there is also a sprinkling of calcareous matter. The various drill records of wells in Cherokee and Crawford counties show that limestone forming conditions were approached many times during the formation of the shales. Little beds from four inches up to twelve or fifteen inches in thickness are often met with, but not regularly enough to be regarded in stratigraphy.

Finally after the 450 feet or more of the Cherokee shale beds, with occasional sandstone beds, had been deposited, the conditions changed and a limestone period was ushered in. The lower of the Oswego limestones, the Fort Scott cement rock, was first formed, then a thin bed of shales, and later the upper Oswego system. These two systems lie so close together they may be regarded as one, for wherever one extends the other does also, with the thin shale parting between. Yet from the bituminous nature of the shales we know that during its formation the conditions must have been favorable for plant growth, hence dry land areas, or marshy conditions must have prevailed.

Above the Oswego limestones lies a bed of shale of variable thickness. In places it is over 40 feet, but the borings at Mound Valley and Cherryvale, and all those made north of Thayer, as well as those north of Fort Scott, show that the shale almost entirely disappears, so that the overlying limestone, the Pawnee, really belongs to the same great limestone forming periods with the Oswego systems. The lateral extent of the Pawnee limestone is fully as great as that of the Oswego as far as can be determined by the deep borings and the surface indications. It reaches all the way from Kansas City to Cherryvale and Independence, and probably much farther. In thickness these three systems vary considerably. At Stover, a well record shows the two Oswego limestones to be 24 and 21 feet. The Pawnee in places west of Fort Scott is more than 40 feet thick, while the majority of the drill records show that the three vary from 5 to 20 feet each.

The remarkable feature of this group of limestones is their great lateral extent, great when expressed in miles, but after all no greater than is common for the limestone systems in Kansas. The outcroppings of the two Oswego limestones are usually about the same. They form cappings to the high bluffs on which Oswego rests, and mark the row of hills southward to the south line of the state. To the northeast this outcropping forms an irregular line which crosses the Neosho river near Oswego, and from there passes about two miles north of Cherokee, half way between Girard and Pittsburg, and beyond to the state line. In many places they are cut through by ravines or broad valleys, so that the Cherokee shales are often exposed over considerable areas to the northwest of this line of outcropping.

The Oswego limestones are rarely if ever horizontal, and their dip is very irregular. They abound in small and low anticlinals and synclinals. They are not conformable with the Pawnee limestone above, and frequently the lack of conformity is due to irregularities in the Oswego limestone.

The line of outcropping of the Pawnee limestone is in general parallel with those of the Oswego limestones. It crosses the east state line south of Fort Scott, passes near Englevale, then north of Girard four or five miles, just east of Brazilton a mile, and from there to the southwest until the escarpment which marks it disappears. It should come in not far from Stover. Possibly the well here, the record of which gave the Oswego limestone 21 and 24 feet in thickness, struck it and confounded it with the other limestones. At Mound Valley it is seen to be below the heavy shale bed which lies between Altamont and Stover.

Above the Pawnee limestone are the Pleasanton shales, which in places approach 200 feet in thickness. They are different from the Cherokee shales in one important particular; their lateral extent apparently is not nearly so remarkable. Their greatest thickness is towards the southwest, while to the northeast in the vicinity of Fontana, and from there northward, they are reduced to only a few feet in thickness. At Boicourt, only twenty miles south of Fontana, they are over 200 feet thick. South of this at Pleasanton they are hardly so thick, but increase to the southwest, and maintain their thickness quite well to beyond the state line south of Altamont.

The Pleasanton shales contain two or more coal seams which are of sufficient extent to have considerable commercial importance, the most notable of which is the one mined at Pleasanton and Boicourt. The total amount of coal which they carry is hard to estimate, but there are many reasons for believing that in the aggregate they are

quite rich in this product. Another interesting feature of these shales is that apparently their upper surface marks the termination of certain portions of the Coal Measure fauna and the beginning of others, as well as slight irregularities in stratification, which have been used in the division of the Coal Measures. According to Mr. Bennett this is the greatest change in the fauna to be found anywhere in the whole Coal Measures of the state. The University Survey has therefore suggested that the Coal Measures be divided into the lower and upper divisions, the upper surface of the Pleasanton shales serving for such a demarkation.

At the close of the formation of the Pleasanton shales a limestone forming period was ushered in. Limestone almost to the extent of 100 feet in thickness was formed in some parts of the state, not in one continuous mass, but separated by thin and relatively unimportant shale beds. This process was carried to the highest degree of perfection in the country to the west of Fort Scott. Here we have three distinct limestone systems one above the other which are so close together that they properly should be regarded as one great system, and hence the name Triple system applied to them. To the south, however, they soon separate considerably so that the intervening shale beds assume considerable thickness. The individual limestone systems also decrease somewhat in thickness and therefore have played a less important role in producing the topography of the country. The lowermost one seems to pass a little above Osage Mission, from there to the left of Parsons a mile or two, and by the way of Altamont to beyond the south line of the state, leaving the great bed of Pleasanton shales between Altamont and Oswego. Throughout this distance the outcroppings of the limestone are not very strongly marked by surface features. The middle of the three limestones likewise passes to the southwest with its eastern margin gradually growing farther from the Altamont limestone, so that it passes near Mound Valley southward to beyond the state line. In this case, however, there is a bold escarpment which marks its eastern limit from the state line northward, fifteen or twenty miles beyond which it gradually merges into a similar escarpment produced by the Triple limestone systems combined. At Mound Valley the vertical distance between the middle and the lower of the three limestones is approximately 125 feet. The uppermost of the three limestones follows a course similar to that of the other two excepting that its eastern boundaries bear to the west more decidedly still and pass near Erie, Galesburgh, Cherryvale and Liberty. Throughout portions of this distance a strongly marked topography results from the combination of conditions produced by this limestone and the underlying shale

bed. For many miles there is a row of bluffs or isolated mounds similar to those in Mound Valley, only more pronounced.

From the vicinity of Uniontown northward the Triple limestone systems remain tolerably close together, passing Mound City, Pleasanton, Boicourt, La Cygne and Fontana, and reaching to the northeast across the state line. Throughout this whole distance the topographic features are similar to those in the vicinity of Mound Valley and Cherryvale, but here they are produced by the Triple limestones serving as a protection above the Pleasanton shales which have their maximum thickness in this vicinity. These limestones as a whole are very interesting in many ways. Their separation to the southward producing the radiated structure is different from that usually found in the state; the uppermost layer thickening so rapidly to the westward from Cherryvale, reaching a thickness of 40 feet at Independence; and the remarkably large masses of flint which they carry, particularly in the vicinity of Uniontown, are some of their prominent characteristics. To the north of where they disappear beneath the surface their existence is shown by the drill record at Paola, and at Kansas City they occur near the surface in the bluffs along the Missouri river. Broadhead* has named the lowermost member the Bethany Falls Limestone, number 78 of his section. According to his report it reaches from the north line of Missouri to Kansas City, from which place it unmistakably extends across the state of Kansas and into the Indian Territory to the south.

Above the Erie or Triple limestone system is another bed of shales which thickens greatly to the south and thins to the northeast. At La Harpe the drill record shows them to be 100 feet thick; in the vicinity of Chanute and Thayer they are fully 150, while farther to the southwest by the way of Neodesha they increase slightly in thickness, so that beyond the Verdigris river at the great Table Mound, near Independence, they measure fully 200 feet, a thickness which they approximately maintain to the south line of the state. But northeastward from La Harpe they gradually become thinner until in the vicinity of Mound City they are only from 20 to 25 feet. These shales likewise carry coal of considerable commercial importance, such as the Thayer coal, and that at other local mines to the southwest which supply large communities, although putting but little fuel on the general markets.

At the close of the period in which the Thayer shales were produced a great limestone forming period was ushered in and the most extensive limestone system anywhere to be found within the Coal Measures of the state, the Iola limestone, was formed. To the south-

* Rep. Mo. Geol. Survey, 1872, p. 77.

west in the vicinity of Elk City it is fully 100 feet thick. Northeast of this it diminishes in thickness until at Iola it is only 40 feet. Still farther northeast it diminishes more, so that in places it is not more than 20 feet thick, but in the vicinity of Olathe it thickens locally to at least 50 feet. Northward from here it reaches to the bluffs along the Kansas and Missouri rivers, is a prominent heavy limestone at the top of the bluff in Kansas City, and extends far to the north and east into the state of Missouri. Its southeastern outcropping marks the crest of a row of bluffs from the south line of the state to the vicinity of Mound City, at which place the Thayer shales decrease in thickness to such an extent that the topographic features due to the Iola limestone coincide with similar ones produced by the Triple limestone.

Above the Iola limestone is a thin bed of shales with no marked characteristics and of but little stratigraphic importance. Above these we encounter the Carlyle limestone, the northeastern limitations of which have not been fully determined. At some places it seems to occur, while at others it is scarcely noticeable. From Iola northward to Kansas City, and thence up the Kansas river to Lawrence, a thin limestone system is found above the Iola limestone which corresponds in position and thickness very well with the Carlyle limestone and quite likely is the same, although exact correlations have not been made.

Above the Carlyle limestone the Lane shales are next reached. They extend almost across the state from Kansas City to the southwest and have an important role in producing the topography along the upper parts of the Pottawatomie river valley. Passing upward from the Lane shales the next formations met with are the Garnett, or Burlington limestones. These are composed of two distinct systems usually separated from 8 to 12 feet by an intervening bed of shale. Their most interesting feature is their great lateral extent. Passing upward from these, the Lawrence shales are next encountered. Here for the first time we have a formation which thickens to the northward and thins toward the south. The Lawrence shales are nearly 300 feet thick at Lawrence and are perhaps less than 100 south of the Neosho river. They even up to a considerable extent the persistent tendency of the lower formations to thicken toward the southwest, and in this way have lifted the overlying limestones to a position more nearly horizontal in a north and south line. Aside from these features they are remarkable for the coal which they carry, as developed in Franklin and in Douglas counties, and particularly for the sandstones which have so many marks showing that they were marginal deposits. Away to the southwest beyond the Neosho river

it is difficult to determine which particular shale bed along the eastern slope of the Flint Hills corresponds to the Lawrence shales, but there is every reason for believing that they extend that far, making their limits at least from Leavenworth to the south line of the state somewhere within the Flint Hills area.

Above the Lawrence shales the Oread limestones are found. These consist of two distinct systems separated by from 14 to 20 feet of shales. To the southwest they have not been fully correlated with the rocks in the Flint Hills area, but they are known to pass beyond the Neosho river. To the northeast they extend to Leavenworth, and from paleontologic evidence Mr. Bennett is inclined to think that the upper one of the two systems is identical with the heavy limestone system at Plattsburg, Missouri.

Above the Oread limestone is a bed of shale a little more than 60 feet thick, after which come the three Lecompton limestones exposed on the hill top south of Lecompton. They are only a few feet thick and are separated by thin shale beds. Above them is another shale bed about 75 feet thick, the two thin limestones exposed at Tecumseh, another shale bed 50 or 60 feet thick, and then the three limestone systems which appear near Topeka. These are of little interest except from their geographic position. Above them lies another shale bed 50 feet thick, at the top of which lies the Topeka coal, a seam about 11 inches thick which has been mined in different places. The coal is immediately overlaid by two thin limestone beds separated by less than 3 feet of shale. Above the limestone is the Osage City shale more than 100 feet thick, at the top of which lies the Osage coal, averaging 18 or 20 inches thick.

The Osage coal is interesting on account of its position. It is about 2200 feet above the base of the Lower Coal Measures, and fully 120 miles from the nearest exposures of the Mississippian rocks. The character of the coal, the shale, and the included sandstones indicate that all these deposits were formed in marginal areas, although so far removed vertically and horizontally from the original marginal seas which existed at the beginning of Coal Measure time.

Above the Osage coal is a thin limestone system superseded in turn by the Burlingame shales, a body about 150 feet thick in the vicinity of Burlingame, and possibly more in places. Both the Burlingame and Osage City shales extend for long distances to the southwest and northeast, and are important landmarks in stratigraphy.

From the Burlingame shales to the Cottonwood Falls limestone, a distance of about 550 feet, there is a succession of thin limestone systems averaging less than 6 feet thick alternating with shale beds of from 25 feet to 75 feet in thickness. The conditions are favorable

for the production by erosion of a rugged physiography, as is well shown along the bluffs of the Kansas river, Mill creek, and at other places.

In our ascent from the base of the lower Coal Measures we finally reach the Cottonwood Falls limestone, a system which extends entirely across the state from north to south, and which is most remarkable on account of its great lateral extent and uniformity of characteristics, particularly so when we consider that nowhere throughout the whole area studied does it vary to less than 5 feet or more than 10 feet in thickness. It is also remarkable on account of its association with an overlying shale-bed which is so filled with invertebrate fossils of characteristic types that it can easily be recognized wherever found. The Cottonwood Falls limestone is most remarkable also for its uniformity of both texture and color, and freedom from lateral and vertical seams. These make it exceedingly desirable stone for building purposes, especially where large masses are wanted. Quarries are operated in it in many localities such as Manhattan, Alma, Eskridge, Americus, Cottonwood Falls, Clements, and other places to the south. The limit in size for rocks obtained is only determined by the demand and the mechanical appliances for operating the quarries. It is within the limits of reason to state that blocks with surfaces hundreds of feet square could be obtained which would be entirely free from fissures or flaws of any description, not only at one quarry, but at many different quarries throughout the state. The topographic features vary so greatly that the limestone is exposed to the surface irregularly over a belt 20 miles or more in width reaching across the state from Manhattan southward. Thus it outcrops on the east at Eskridge, while the broad valley of Mill creek cuts downward to it 20 miles away. It approaches to within a few miles of Emporia, and is again found at Clements 30 miles to the west, with many quarries at intervening points. The division between the Permian and the Coal Measures has not been located definitely, but will probably be placed not more than a hundred feet above the Cottonwood Falls limestone, as the paleontologic evidence upon which such a division must depend seems to show that the greatest change of marine invertebrate life occurred not long after the formation of the existing fossiliferous shales overlying the Cottonwood Falls rock.

## RATIO OF LIMESTONE TO SHALES AND SANDSTONE.

We have now given a hasty review the successive formations as they occur one above another from the surface of the Mississippian to the Cottonwood Falls limestone which marks the extent of areas

examined during the past two summers. Let us now give a short consideration to a few subjects which have not yet been mentioned. First, the relative amount of limestone, sandstone, and shales for the average or general section may be determined by a glance at plate XX. It will be seen that for the whole of the Coal Measures, both lower and upper, the ratio of limestone to the other materials approximates 1 to 3.8. This is interesting on account of the unusually large amount of limestone in the Coal Measures. If we consider the lower Coal Measures alone the result is somewhat different, for the great thickness of the Cherokee shales so completely overshadows anything found in the upper Coal Measures that the relative amounts of limestones are greatly reduced. But even here we have a ratio of 1 to 8, which is fully as much as that given in most localities for the whole Coal Measure area, and for the Upper Coal Measures of 1 to 2.4.

## CHARACTERISTICS OF THE LIMESTONE.

Next let us consider the character of the limestone as a whole. The Oswego limestones have been mentioned in different places as exceedingly compact and semi-crystalline throughout, and are particularly noted for their characteristic fauna. The lower one of these two members in many places is one solid mass throughout, having no division into layers as limestones so often have; further, it is characterized by slight impurities which render it valuable for the manufacture of hydraulic cement, the only limestone in the state thus far discovered possessing these properties. The upper member of the Oswego limestone, on the contrary, is more nearly normal in the matter of division into layers, but in many places is sufficiently crystalline to take a fairly good polish.

The Pawnee limestone as exposed in the vicinity of Fort Scott is massive in its nature and weathers into large blocks which are different from those of any other system observed in the state, and closely resemble similar blocks of weathered origin seen along the bluff capped by the Iola limestone. But a closer examination of such boulders would determine at once that they differ from the Iola limestone in many respects. Both north and south from Fort Scott this massive character of the Pawnee limestone gradually disappears so that it more closely resembles other limestones.

The Triple limestone system in the vicinity of Uniontown is characterized in two particulars. One is the great abundance of flint nodules which it contains, particularly the middle system. No place in the state is known to the writer, not even in the flint beds of the Permian in the vicinity of Florence or Fort Riley, which carries a

large ramount of flint nodules nor larger masses of flint than do these beds in places a few miles to the west of Portervale. The other characteristic referred to is the almost complete crystalline structure which the Triple limestone in places seems to possess. There seems to be an association in some way between the degree of crystallization and the abundance of flint, so that near Uniontown the crystallization is also highly developed. This association is looked upon as only a matter of coincidence.

The Iola limestones are remarkable in four ways: First, their great thickness; second, their great lateral extent; third, their unusual freedom from both lateral and vertical seams; and fourth, their high degree of crystallization. The freedom from either vertical or lateral fissures is so great that in the quarries at Iola immensely large blocks can be obtained which show no signs of fissures of any kind. This property is also recognizable along the outcroppings of the rock on the summit of hills, the masses which break loose and begin working their way downward are remarkable for their great size. In many places such masses measure from 20 to 50 feet across and doubtless in extreme cases, as at Table Mound, they are even greater. In degree of crystallization almost throughout the whole of their extent within the state at least two-thirds of the mass of calcium carbonate exists in the crystalline state. This permits one to recognize them in many instances. In a few places only, as around Fontana, does this crystalline structure decrease to normal conditions.

The Burlington or Garnett limestones have characteristics which are of no special importance, excepting in the vicinity of Lane where the Lane quarries occur. Here they assume a crystalline structure and a degree of compactness which render them unusually valuable for building material. Even more, they are susceptible of taking a high polish, so that they are serviceable for pedestals of tombstones, monuments, and other ornamental work. This property has given to them the title of "marble." The upper one of the Oread limestones is noted for the large amount of flint which it carries, in some places almost equaling the ordinary proportion of flint in the famous Flint Hills limestone. It is also characterized as remarkably compact, as already pointed out, and is exceedingly rich in faunal contents.

In passing westward, shortly after leaving the horizon of Topeka, a marked change begins to be perceptible in both the limestones and the shales. The limestones begin assuming that peculiar buff color which is so characteristic of the Permian rocks, a color which must be observed to be understood; while the shales also begin parting with their dark carbonaceous or bituminous appearance and gradually grade into the lighter yellow or buff characteristic of the Permian

shales. In this way the physical change is gradual, so that there is no sharp division line in the general characteristics of the upper Coal Measures and of the Permian formations.

## CHARACTERISTICS OF THE SANDSTONE.

The sandstones throughout the whole Coal Measures are exceedingly variable and uncertain, the ease and frequency with which they grade into the shales and back again into sandstones is noticeable on every hand. As has been stated, this property is so marked that for stratigraphical purposes they are practically useless. In only a few places can any particular sandstone formation be traced in a northwest and southeast direction exceeding ten miles. The most noted of these exceptions is in the vicinity of Redfield and Farlington where the great flagging-stone beds occur over so wide an area. The conditions of these flags show that they were formed in marginal areas not very far from shore. Again in the Thayer shales we have large masses of sandstone which from their coarse structure must have been deposited close to shore. The frequent coal seams within the Thayer shales which are intimately associated with the sandstone show that shallow water and other conditions favorable for plant growth obtained at different times throughout the shale forming period. In the Lane shales we have another instance of great sandstone deposits having been produced. These are most marked in the vicinity of Burlington and to the southwest. But here the topographic features show conclusively that there was no persistency of sandstone deposits over any considerable area. A sandstone hill here, a valley there, and a hill again beyond can be accounted for, in the absence of any other evidence, only on the assumption that the valleys mark locations where the sandstones had graded into arenaceous shales, or in someway had assumed properties which made them yield more readily to erosion. Above the Garnett limestone we have the Lawrence shales, another great shale bed with many included sandstones in places. These to a much greater extent than any studied below them have ripple marks and rain-drop marks with wonderful frequency. No sandstone bed has ever been examined by the writer which contained more conclusive evidence of having been produced in shallow water than these. Not a single instance is known in which a sandstone has any commercial value, for they are friable, argillaceous, unevenly bedded, exceedingly variable in texture, and possess many other properties which deprive them value as a building stone.

Passing upwards from here, in the vicinity of the Osage City coals we have another great shale bed with many sandstones interspersed which bear an abundant evidence of being produced in shallow

water. One of these is the great abundance of amphibian tracks which have made them of considerable importance as museum specimens. Years ago the late Professor Mudge purchased them by the car load for Yale College and other eastern institutions.

Above this the principal evidence we have of successive submergences consists in the alternation of limestone and shale formations. As the shales have less bituminous matter than those below it is quite possible that they do not represent a period of emergency. But of the various shale beds below the Osage City coal not one has been studied which did not have either seams of coal or rich bituminous shales somewhere throughout its extent. These may be looked upon as good evidence that each one of them registers a period of emergence, or at least almost complete emergence from the ocean waters, while the succeeding limestones have evidently marked complete submergence below the ocean water. In this way we have conclusive evidence of at least 25 alternations from ocean water conditions to that of dry land or very shallow water periods having been produced between the close of Mississippian time and the formation of the Cottonwood Falls limestone, with a strong probability that many more such oscillations have occurred.

## EXTENT OF MARGINAL AREA.

If we now try to determine what portions of the Coal Measure area were marginal in origin and what ones were produced in deep water it would seem we are compelled to admit that the marginal and deep water formations alternate with each other throughout the whole Coal Measures. The great Cherokee shales were probably principally marginal in their position during their formation, but from their excessive lateral extent in every direction they must have occupied a very broad or shallow ocean area or fresh water lagoons. Equally the shales including the Osage City coals have just as positive markings of marginal areas in the amphibian tracks so abundant within them, as has been already pointed out, as have also the intervening shales.

## INCLINATION OF STRATA, FISSURES AND FAULTS.

Another interesting feature of the stratigraphy of the Coal Measures is the relative positions of the different formations with reference to inclinations and dip. All of the lower formations approximate a position parallel with the upper surface of the Mississippian series. There is not a single instance of any marked unconformity throughout the whole Coal Measures, neither is there an instance of absolute conformity between any two adjacent limestone systems. There is

scarcely a township in the whole area which does not have an instance of an anticlinal axis or synclinal trough, yet such anticlinals and synclinals are of such limited extent and of such low angles of inclination that they are of but little importance. The greatest inclination known anywhere scarcely reaches four degrees, and occurs in the Cottonwood Falls limestone and associated formation a few miles west of Strong City. Considerable effort was made to determine the cause for these various irregularities. In most instances the conclusion was reached that the primary cause was the inequalities of the ocean bed on which the deposit was formed. In the production of ocean beds one can readily understand how a slight inequality in the distribution of the shale forming materials would leave an uneven surface for the limestone which succeeds it, and that correspondingly a lack of regularity in the production of calcareous matter would equally produce an irregular surface of the limestone for the succeeding shale bed to rest upon. The directions of the anticlinal and synclinal axes were variable, the most prominent one being approximately at right angles to the line of outcropping of the various formations. Those mentioned at Cottonwood Falls, trend north and south, and possibly are due to slight orographic movements long after the rocks were formed.

A few faults are known within the Coal Measures, but none of any considerable extent. The Cherokee shales have numerous faults with vertical displacements sometimes reaching 18 or 20 inches. The Lawrence shales likewise have some such faults. One is positively known to exist in the vicinity of Sibley. Mr. Bowman while following a 14-inch seam of coal a few feet under the surface was surprised to find it suddenly disappear. By digging downwards about 3 feet, however, he came upon the same coal bed which had been displaced to that extent. It is quite probable that detailed investigations throughout the Coal Measure area will detect many similar faults and possibly even greater ones, although the almost perfect harmony of stratification found along the lines of the different sections run by this Survey, sections which cross each other in so many different places, and which trend in so many different directions, would seem to positively establish the absence of any very considerable faults throughout the whole Coal Measure area.

Neither is there any considerable evidence of regional or dynamic metamorphism anywhere within the Coal Measures of the state. Only one locality has been found which at all approaches anything of this nature—the once famous "silver mines" in Woodson county. Diligent search was made by all the observers in every locality for marks or traces of metamorphism of any kind, or other indications of disturbances of volcanic or eruptive nature, but nothing whatever was seen.

## SHALES, PRINCIPALLY SUB-MARINE IN ORIGIN.

There is no fundamental reason why great shale beds may not have been formed under great fresh water lakes, or fresh water lagoons of varying depths. The shales in the Coal Measures of Kansas, however, probably were principally deposited under salt water. Two general reasons have led to this conclusion. The first is the great frequency throughout almost all the shale beds of traces of calcareous matter. Many little limestone layers are found which vary from 2 to 10 or 12 inches and which rarely are sufficiently pure to be called limestone. Such formations generally have well preserved marine invertebrate shells within them, showing that they were formed under ocean water. Were all of such formations within the Cherokee shales counted they would probably number 20 or 30. In other shales similar conditions obtain, so that the great mass of the Coal Measure shales either were deposited principally under ocean water or the number of emergences and submergences were manifold greater than the estimates given in the earlier pages of this paper.

The second reason for believing the Coal Measure shales were deposited beneath ocean water is the great frequency of salt water within them. Not a single instance is known to the writer of water having been obtained at a depth equal to or greater than 200 feet within the shales which was not more or less salty. With the recent extensive prospecting for oil and gas dozens of wells have been drilled, so that the test can be made quite thoroughly over the area prospected. Farther to the west the conditions in this respect seem to be about the same. The deep well at McFarland produced an abundance of salt water, while according to Hay* those at St. Mary's and Wamego seem to have pierced 3 or 4 feet of rock salt. The same author states† that at La Cygne 80 feet of rock salt was passed in a deep well. The writer investigated this matter during the past season and reached the conclusion that there was no satisfactory evidence of rock salt anywhere within the shales passed by the well, but that the production of strong brine here was similar to that in so many other wells. However, the presence of rock salt would only add strength to the argument here deduced. It is difficult to understand why the salt water would be so universally obtained over an area so many hundred square miles in extent excepting by assuming that the shales were deposited under salt water and retaining a portion of the same, the salt of which has since been dissolved by percolating waters, and is brought to notice when the wells are drilled. As almost every shale bed from the Mississippian to the Cottonwood

*Geol. and Min. Resources of Kans., 1893, p. 43.
†Loc. cit.

Falls limestone has produced salt water, the argument is as applicable to any one as to another.

## GENERAL CONDITION OF DEPOSITION.

From the foregoing arguments and conclusions it is evident that throughout the Coal Measure time the conditions over that part of the globe now occupied by the Coal Measure formations of Kansas were exceedingly variable, yet changed in a cycle-like manner, so that any one condition had periods of recurrence, thereby duplicating results quite a number of times. It has been pointed out that no less than 25 different limestone forming periods occurred, and also a similar number of shale and sandstone forming periods. The geographic and geologic positions of the different kinds of rocks produced also have been given as covering a great range. Thus the Burlingame coal is more than 100 miles geographically and nearly 2000 feet geologically from the coals in the Cherokee shales, and yet practically the same set of conditions obtained during the formation of both. Attention has also been called to the general thickening of so many of the formations to the southwest, as represented by the Pleasanton shales, which more than double their thickness, the Independence limestone, which quadruples its thickness, and the Iola limestone which increases from 40 to more than 100 feet. That the sandstone formations also thicken in a similar manner has been illustrated by the Lane shales which carry the heavy sandstone beds in the vicinity of Burlington. But the Lawrence shales have been pointed out as reversing this general order, for they thicken from near 100 feet at the Neosho river to 300 at Lawrence.

Now an interesting question arises as to what conditions must have obtained in order to produce so widely diversified results over so great an area. The frequent recurrence of sandstone with ripple marks and rain drop markings throughout the whole area and vertical distance can only be accounted for by admitting the frequent existence of shallow areas or lagoons under which such sandstones were deposited. The drill records of the many dozens of deep wells recently sunk only emphasize this statement; for not a single well has been drilled which did not pass through many different sandstone beds widely separated, often by heavy sandstone systems. It would seem that we must have a great period of intermittent subsidences, with the greatest variation in elevation taking place to the south and west, while nearer the borders of the Mississippian the vertical oscillations were much milder. From paleontologic evidence it would seem that the great limestone forming periods usually were abruptly closed; for as Bennett has pointed out the great

abundance of fossils is generally found near the summit of the several limestone systems. Further, it is well known that the fossils rarely extend into the shales immediately overlying the limestone, that when fossil bearing shales are found they usually are separated from the fossiliferous limestone by a barren area of variable thickness, although there are a few notable exceptions which have been mentioned, such as the bituminous shales just above the Fort Scott cement rock, and the exceedingly fossiliferous shales first above the Cottonwood Falls limestone. It would seem that such conditions can best be explained by considering that each limestone forming period was brought to a close by a sufficient elevation of the ocean bottom either to destroy the various existing forms of invertebrate life, or to cause them to migrate to deeper waters beyond the limits of the Coal Measure area as now exposed. Had the climatic conditions on the existing dry-land area changed so as to produce greater erosion, and the consequent greater sedimentation, thereby destroying the invertebrate life, the most opportune conditions would then have obtained for the preservation of the shells of the different animals whose lives were thus destroyed.

It would therefore seem that the conditions in Kansas require many gentle oscillations, both subsidence and elevation, with the greatest movement to the west, and the least to the east. In this way we would expect to find different systems of different kinds of rocks possessing a wedge shaped outline with the edges to the east. Such is almost universally the case. In two cases thin limestones have been found which entirely disappear eastward without being cut off by erosion. One is a limestone covering considerable portions of the surface from 1 to 2 miles east of Mound City. It completely disappears before Pleasanton is reached, and does not appear in the walls of the bluffs between the two towns. The other comes to a feather edge in the bank by the side of the wagon road just south of Hillsdale.

Winslow* has discussed this subject for Missouri, and coal fields in general, and has shown how many features like those observed in Kansas may be explained by assumptions similar to those above made. The almost perfect continuity over such wide areas of our limestone systems and great shale beds, as revealed by the drill, teach, however, that the oscillations occurred in such a manner that unconformities of any considerable extent were not produced. For a full discussion of this phase of the subject the reader is referred to the article above mentioned by Winslow, pages 23 to 32 inclusive, and to a more elaborate article by the same author in the Bulletin of the American Geological Society, volume three.

*Preliminary Rep. on Coal: Mo. Geol. Surv. 1891.

But there is one point in connection with this subject which is difficult to understand. The strata as now observable dip uniformly to the west. If they were laid down in a horizontal position the only way this could be brought about would be for the sum total of the uplift to the east to exceed that to the west. If during the period of formation a line of stationary position was maintained along the shores of the then existing Mississippian series, to the west of which there was a general subsidence, but each rock system formed on the horizontal, it would seem that no movements could leave such formations higher vertically than the border of no variation along the coast without causing such formations to dip to the east. A vertical section drawn normal to the line of no variation would cut it in a point which may be looked upon as the projection of an axis of rotation.

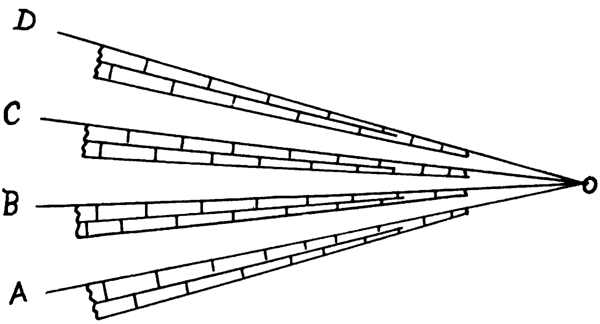



Fig. 1.

This is best explained by reference to figure 1. Let O be the intersection of the vertical section with the marginal line of no oscillation during the period of Coal Measure time, and the lines OA, OB, OC, and OD represent different systems. Now if OA was horizontal when formed it might be brought to its present position by continuous subsidence to the left; so also might OB, OC, etc., so that they would all dip to the west. But when the final period of elevation came it would be impossible to lift the western portion of OD to a greater height than that to which O was carried without causing it to dip to the east. If we suppose that the point O was elevated 1000 feet above the sea level, then D may also be lifted to that height without passing beyond the horizontal. But in Kansas the present surface in the Flint Hill region in places reaches 1700 feet or more above sea level, and yet the uppermost surface strata dip westward nearly 10 feet to the mile, which, were they extended eastward would take them more than 1500 feet above the highest hills in the Ozark uplift, a position which very probably they never occupied.

But if we assume that the different systems were deposited on an ocean floor itself inclined to the west, and add the subsidence already

spoken of to this, we would have a condition which would admit of the western portions of such systems being elevated so that parts of them were far above sea level without giving them an inclination to

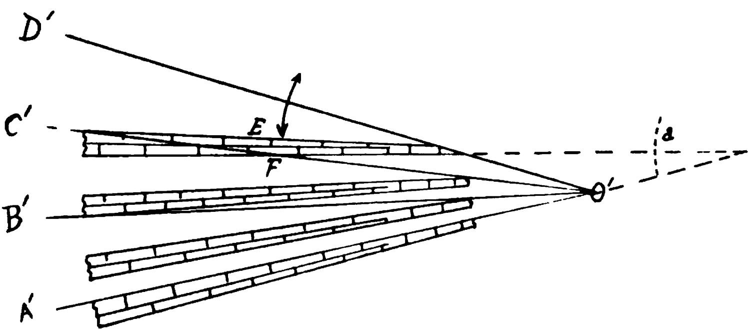



Fig. 2.

the east. Figure 2 will make this plain. Let O' be the point coinciding with O in figure 1 and the lines OA, OB, etc., represent the horizontal at different periods in Coal Measure time. Now while OA was horizontal suppose the Cherokee shales were deposited on an ocean bottom that was about horizontal. While OB was horizontal suppose the Iola limestone was formed on an ocean bottom inclined 10 feet to the mile. But to obtain the latter, OA must have been depressed. In a similar manner let each succeeding higher formation have a slightly increasing dip due to ocean subsidence until 20 feet to the mile is reached by the upper Permian. The Flint Hills are about 150 miles west of the probable location of the point O'. Now if we elevate O' about 1000 feet, and E an equal amount plus 10 feet to the mile, the Flint Hills will be lifted 2500 feet above sea level and still have an inclination to the west of 10 feet to the mile for their strata. If this explanation is the correct one we would have to find that the upper members of the Permian have a less dip to the west than the lower Coal Measures, for the total *angular* elevation cannot have equalled the depression. Mr. Adams has shown that this is true. The upper surface of the Mississippian dips to the west fully 21.5 feet to the mile. Above this there is a general decrease, the Iola limestone dipping 17 feet to the mile, while in the Flint Hills region the dip is about 10 feet to the mile.

The only reason why in this explanation it is assumed that the lower members were deposited more nearly horizontal than the upper ones is that the difference is so slight, as they are now found, that had each been given the same dip when formed the continued subsidence to the west would have given the lower members a much greater excessive inclination than they now possess.

Winslow,* and also Keys,† while discussing this subject assume that the coastal area was subsiding rather than the ocean area. By such assumptions it is difficult to understand how such a condition could result in producing the uniform western dip which characterizes all the formations in the Kansas Coal Measures. But a still greater difficulty is met in accounting for the westward progression of the marginal areas. Had the coastal borders continuously subsided the marginal areas would as continuously have migrated landward, while the facts are they migrated oceanward at a sufficient rate to equal 125 miles during the formation of 2200 feet of sediments, as will be seen by comparing the Cherokee shales with the Osage City shales. In this way the point O in figure 1 also migrated oceanward and upward which would assist all the more in accounting for the westward dip over the present areas of high elevation.

*Mo. Geol. Surv. Rep., Coal, 1891, pp. 21-32, and Bull. G. S. A., Vol. III, pp. 109-121.
†Ia. Geol. Surv. Rep., Vol. II, 1894.

# Division of the Kansas Coal Measures.

BY ERASMUS HAWORTH.

So many different plans have been followed by geologists of the Mississippi valley in dividing the Coal Measures that one who is laboring in a new field has no positive criterion by which to be guided. By some the Coal Measures have been divided into two divisions, the Lower and the Upper; by others into three, the Lower, Middle and Upper. Rarely have the same division lines been made, or the same bases of classification been used, so that we are left in doubt in almost all instances why any particular division was made at any particular place. According to the different State Reports of our nearest neighbor to the east, Missouri, Broadhead used a sandstone with no special characteristics as the division line between the Lower and Middle Coal Measures, and a second sandstone of equally unimportant characteristics for the division line between the Middle and Upper. Why these particular sandstones should be chosen rather than other formations he does not say, neither are we informed why the whole Coal Measures should be divided into three divisions rather than into two, or four, or any other number. Winslow in his more recent Report does not attempt to divide the Missouri Coal Measures at all, but he does not take ground against it, so the reader is left in doubt to a certain degree regarding his views on the subject. But Dr. Keyes, in volume II of the Iowa Report, 1894, brings up strong objections to the older method of division, and suggests what seems to be a better basis of division, provided one is used at all. We shall have occasion to refer to this later in this paper.

It would seem reasonable to assume that in all matters of divisions and sub-divisions of the Coal Measures the same general methods be adopted and the same principles followed that are used in determining the number and locations of the sub-division lines of any other great geologic formation. The custom of geologists of all countries is practically the same in this. At least one of two conditions is always required to make a division which in application is more than local. One of the conditions is that there must have been a break in the succession of formation, a time break, indicated by general unconformity, such as is produced when a surface is lifted above ocean water and more or less eroded before later formations are placed upon them, or when considerable orographic movement has

occurred leaving the strata already formed in an inclined position, so that the new formations will not be conformable with them. The other condition accepted universally as a sufficient basis for making a division or sub-division in stratigraphy is a positive variation of any character in the flora or fauna of the formations concerned. There may be grounds for difference of opinion, or difference in custom regarding the degree of variation which should obtain, but all admit that if the change is sufficiently great a division of the formation should be made, either with or without unconformity.

The Coal Measures of Kansas are 2750 feet thick, and cover an area of approximately 20,000 square miles. It would seem desirable, therefore, for the sake of convenience to subdivide them into two or more groups. But when a section of country has been studied in sufficient detail to trace the different great classes of formations across the whole area, and to determine their limits vertically, as has been done for the Kansas Coal Measures through the assistance of the numerous deep wells which have recently been drilled in our state, it becomes possible to make many sub-divisions to which local geographic names can be applied, thereby in great measure limiting the convenience which may be derived from other kinds of sub-divisions. It is doubtful whether any real convenience will arise by making any division of our Coal Measures other than those already made and to which local geographic names have been assigned, for it is now possible to speak exactly with reference to any portion whatever of our Coal Measures anywhere in the state by a proper use of the terms already introduced.

It is the concerted opinion of the different individuals who have been engaged with the writer in field work that the Kansas Coal Measures should be divided into two divisions, which may be designated as the Lower and the Upper. Careful search failed to discover any considerable unconformity anywhere between the Cherokee shales and the Cottonwood Falls limestone, yet, as has already been pointed out, slight unconformities exist everywhere. The uppermost members of the Coal Measures are quite different from those situated at the base, but the transitions of all physical properties seem to be gradual rather than abrupt.' This gradual change is shared by the coal itself. The variations in lithologic characters are mere repetitions from limestone to shale and sandstones, and then back to limestone again. It is apparent to every member of the Survey that unless the change from shale to limestone, or limestone to shale would warrant a division, nothing in the line of physical properties throughout the whole Coal Measures could be used as a basis. But when we turn to the side of paleontology we are not so wholly

deprived of variations. The great familiarity Mr. Bennett has possessed for years with the invertebrate fauna of the Coal Measures of Iowa, Missouri, Kansas and the Indian Territory made it an easy matter for him to point out a horizon at which there was a considerable abruptness of faunal variation which seems to be sufficient to warrant a division of the Coal Measures.

According to paleontologic evidence obtained by Mr. Bennett, there is quite a faunal change at the top of the Pleasanton shales. One species *Chonetes mesoloba*, which is very abundant and wide spread below this line cannot be found above it anywhere in the state. Not only this, but different species first appear in the Erie limestone, thus making a change of considerable importance in the fauna at this line.

This unusual faunal change is accompanied by as great physical changes as can be found at any line. It has the great bed of the Pleasanton shales below it and the Erie or Triple limestone group above it, each of which has been traced entirely across the state from Kansas City to the south line. In addition to this the same two formations reach, according to Broadhead, from Kansas City northwards to the border of Iowa, the lower member of the limestone series being known as the Bethany Falls limestone, number 78 of Broadhead's general section. They also extend in undiminished thickness to the west under the surface as far as can be determined by the various deep wells, with no reason of doubting their uninterrupted extension for a hundred miles or more beyond.

To sum the matter up in a few words, it is proposed to divide the Coal Measures of Kansas into two divisions, to be designated by the terms Lower Coal Measures and Upper Coal Measures, the division line to be at the top of the Pleasanton shales, which is at the bottom of the Erie or Triple limestone, the basis of division to be principally paleontologic, but also partially dependent upon the great physical change which marks the line between the two extensive and characteristic formations, the Pleasanton shales and the Erie limestone.

This division does not correspond with either one used by Broadhead for the Missouri Coal Measures. His division between the Middle and Upper is a sandstone situated a little below the Bethany Falls limestone and therefore a little below the line here proposed. Why Broadhead should have chosen sandstone to mark his division line cannot be understood, for, at least in Kansas, all the Coal Measure sandstone is so limited in its extent that it can be used for no lines of demarkation whatever, excepting for the most local divisions.

In his excellent Report on the coal deposits of Iowa Dr. Keyes*

*Ia. Geol. Surv.. Vol. II. 1894.

has adopted in a general way the principles first enunciated by Winslow† which have already been referred to in this number of the QUARTERLY. It assumes that throughout Coal Measure time there was a gradual but irregular subsidence of both the ocean bottom and land areas under the Coal Measure areas, and that the subsidence occurred principally near the shore lines, so that as fast as the sedimentation from the land area would bring the new formed strata

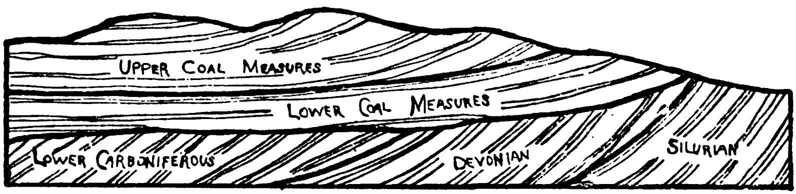



Fig. 3.
Representing the ordinary idea of the division of the Coal Measures. (After Keyes.)

near the surface additional subsidence would occur, and in this way a continuous series of marginal formations would be produced, the older of which would be farther oceanward than the younger. He has gone farther than Winslow and has suggested that the natural division of the Coal Measures would be a line running diagonally to the stratification, placing all of the marginal areas in one group and the deep sea areas in another, as represented by figures 9 and 10 on page 162 of his Report, which are here reproduced as figures 3 and 4.

The conditions in Kansas will not admit of such a classification for the following reasons: First:—According to the Keyes explanation the later, and consequently younger, marginal areas would be land-

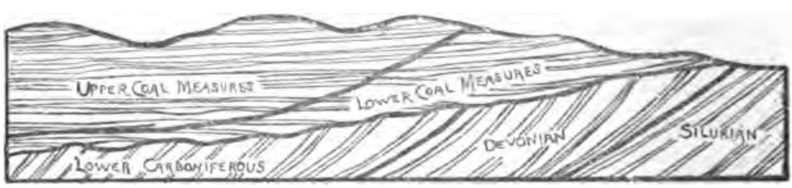



Fig. 4.
Representing Keyes' idea of the division of the Coal Measures. (After Keyes.)

ward from the earlier and older. But we have undoubted evidence that the land area for Kansas in Coal Measure time was the Mississippian to the southeast, while the later marginal areas are now found much farther to the west, as is illustrated by the Osage City shale beds and coal which are from 100 to 120 miles to the west of the present western exposure of the Mississippian formation. Second:—The universal westward thickening and eastward thinning of all the

† Mo. Geol. Rep. Coal, 1891, and Bul. G. S. A., Vol. III, p.

formations, as argued by Winslow, is of such a nature that we cannot admit the earlier existence of the Coal Measure formations very much farther to the southeast than their present limits, so that we cannot account for the marginal formations in the various places where they are known to exist in such widely scattered localities without assuming that there was a relative elevation of the coastal areas rather than a continual subsidence, as Keyes assumes. The Cherokee shales are marginal in their character; so are the Pleasanton shales, the Thayer shales, the Lawrence shales, and the Osage City shales, each in turn being located continually farther oceanward from the position occupied by the coast at the beginning of Coal Measure time. There is a strong parallelism between this and the relative positions of the outcroppings of the great geologic formations of America which are generally explained on the assumption of a gradually rising continent or a gradually subsiding ocean bottom. Third:—We have abundant evidence, based principally upon accurate records of many deep wells, that each of the great formations, both shale and limestone, is continued uninterruptedly far to the west. Fourth:—Any division plane of the Coal Measures which would pass diagonally to the stratification of the formations would be unnatural and would correspond in principle to passing a plain diagonally to the stratification lines which separate the Silurian from the Devonian, or the Devonian from the Mississippian. Both of these latter great formations have portions within them which were marginal in origin and others which were formed under deeper ocean. But no one could entertain the thought of basing the greater classifications on such properties as these. The different formations in the Kansas Coal Measures lie as regularly one above the other as do the different formations in any great geologic group in America. The faunæ of the successive limestone systems show a gradual transition in the forms of animal life from the ancient toward the more modern, which strongly indicate that all of any one limestone system is older than the systems above it and younger than those below it. A division plane which would cut these diagonally would therefore be at variance with the accepted rules of time classification.

For all these reasons, and others which might be added, it seems that it is both unnatural and undesirable to divide the Coal Measures of Kansas otherwise than by a method at least similar to the one herein adopted.

# The Coal Fields of Kansas.

BY ERASMUS HAWORTH.



## AREAL EXTENT OF COAL FIELDS.

According to the Report of the State Mine Inspector for 1893, seventeen different counties in the state have produced coal in sufficient quantity to be considered of commercial value. Five of these are located west of the Coal Measure area and produce the brown coals or lignite in small quantities. The remaining twelve are located in the Coal Measures proper and are:—

| | | | |
|---|---|---|---|
| Atchison, | Cherokee, | Franklin, | Linn, |
| Bourbon, | Coffey, | Labette, | Osage, |
| Chautauqua, | Crawford, | Leavenworth, | Shawnee. |

It will be seen that they are widely scattered over the eastern part of the state. To this list a few names should be added to correctly represent the geographic extent of workable coal within the state. The Report above referred to included only those counties in which coal mining was actually conducted to a greater or less extent during 1893. The extent of the coal, however, is not dependent upon cheap freight rates nor proximity to thicker and better veins, while the markets and consequently the mining operations are. The following counties are known to have considerable coal in them and should be added to the above list of twelve:

| | | |
|---|---|---|
| Douglas, | Lyon, | Neosho, |
| Elk, | Montgomery, | Wilson. |

Each of these has coal to a sufficient extent to justify local operations, usually the "strip pit" method. In some of them the mining is practically discontinued on account of the cheap coal shipped in from the larger mines, while, could the same coal be located in the western part of the state, it would be a fortune to its possessors. The coal beds of Douglas county may be used as an example to illustrate this. A fair quality of coal in veins from 12 to 16 inches in thickness was formerly mined to a considerable extent in half a dozen or more localities a few miles to the southeast of Lawrence. But with equally good or better coal shipped from Leavenworth and placed upon the retail market at from $2.75 to $3.00 per ton, the local mining had to be abandoned, except here and there where a few farmers obtain their winter's supply of fuel.

In the counties above enumerated the coal is or has been principally mined at or near the following places:

*Atchison.*—About 3 miles south of the city of Atchison; the vein has an average thickness of 15 inches; mining operations began in 1893.

*Bourbon.*—The mines are principally operated to the southeast, east, and northeast of Fort Scott, and the product is known in the markets as the Fort Scott "red" coal.

*Chautauqua.*—Mines located near Leeds in the northwest part of the county. The operations are principally conducted to supply the local trade. The vein is from 12 to 18 inches thick, and therefore will not admit of operating for the general market.

*Cherokee.*—This is the second heaviest producing county in the state. The principal mines are located in the environs of Weir City, Cherokee, and the southwest, where three different veins are operated, and farther to the southeast in the vicinity of Columbus, Crestline and Tehama, where a 14-inch vein is operated for local consumption. At least four different veins of coal are operated in the county.

*Coffey.*—Mines located in the vicinity of Lebo. The coal is 14 inches thick and operated for local trade.

*Crawford.*—This is the heaviest producing county in the state. The mines are situated around Pittsburg and to the northeast and southwest. Two veins are usually operated and in some places three.

*Douglas.*—Mining operations almost abandoned. Mines located in the vicinity of Sibley and Blue Mound. The coal vein is from 12 to 16 inches thick, of fair quality, and formerly supplied a considerable local demand, but has been driven out of the market by cheaper coal shipped in from Leavenworth and other places.

*Elk.*—Small quantities of coal have been found in the vicinity of Grenola which has been mined to a limited extent for the local trade.

*Franklin.*—Coal of good quality and apparently in great quantity exists in different localities to the west and southwest of Ottawa. It is mined principally near Pomona and supplies the country trade, is extensively teamed to Ottawa, and limited quantities are shipped into the general market.

*Labette.*—The coal is found in the vicinity of Oswego and to the north and south. It is in veins about 15 inches thick and is mined by the "strip pit" method to supply the local market.

*Leavenworth.*—A 22-inch vein of coal is mined in and about Leavenworth city by shafting to a depth of between 700 and 800 feet. This county ranks fourth in the per cent. of its output.

*Lynn.*—The coal in this county is obtained from Pleasanton, Boicourt, La Cygne, Mound City, and a few other places, usually by shafting but sometimes by the "strip pit" method. The county ranks fifth in output for the state.

*Lyon.*—Years ago small deposits of coal were found in the east part of the county and were operated for local trade. Recently, however, the operations have been abandoned.

*Montgomery.*—Considerable coal exists in this county to the southeast of Independence, and also to the north towards Neodesha. It is only mined locally and the cheaper fuel from the larger mines has almost put a stop to this.

*Neosho.*—Thayer is the center of the coal mining district in this county. The mines are principally located to the west near the border of the county. The coal vein is from 15 to 20 inches thick, and large quantities are obtained for Thayer and surrounding towns, and for the country trade.

*Osage.*—Coal is mined at many points along the Atchison, Topeka & Santa Fe Railway between Topeka and Emporia, with Carbondale, Scranton, Burlingame, and Osage City the principal mining centers. The mines are operated by both the "strip pit" and the shaft methods. This county stands third in per cent. of output.

*Shawnee.*—The mines are located just west of Topeka and near Silver Lake and Dover. Mining is done by both shafting and drifting. The coal veins average about 13 inches in thickness.

*Wilson.*—The coal is situated to the southeast, east, and northeast of Neodesha. The mines are operated quite extensively for a local trade. The veins vary from 12 to 18 inches in thickness, and furnish coal which is placed upon the market at almost as low rates as anywhere in the state.

## THE GEOLOGIC POSITION OF THE COAL BEDS.

### THE CHEROKEE SHALES.

More than 75 per cent. of all the coal mined in the state comes from the Cherokee shales situated at the base of the Lower Coal Measures. These shales contain many different veins of coal, in fact they are so numerous that were all the lesser ones considered they would probably reach twenty or thirty in number. The veins which are worked to a considerable extent in Cherokee county are only four, while to the north in Crawford county only three have been operated. About 175 feet above the base of the shales is the Columbus coal. The vein is variable in thickness, but will average from 12 to 15 inches. It lies just under a relatively heavy sandstone which caps the plateau and hills east and southeast of Columbus. The sandstone is cut through in almost every quarter section by one or more little streams or ravines so that the coal is exposed along the brow of the hill in dozens of different places. The coal bed seems not to be uniform in its extent, so that occasionally it is wanting in areas covered by the sandstone. This coal vein was operated in the early days of the settlement of Cherokee county several years before the heavier veins above were discovered.

Near the middle of the Cherokee shales the heaviest vein of coal known in the state occurs. It is extensively mined along a belt reaching from a few miles southwest of Scammon to beyond the east line of the state by the way of Weir City, Pittsburg, and other prominent mining towns. It outcrops to the southeast and dips to the northwest at an average of about 17 feet to the mile. It is usually known as the lower Weir City-Pittsburg coal. Its thickness, which is remarkably uniform, averages fully 40 inches with an occasional maximum thickness of 4 feet or more. It is also the best coal in the state, as will be shown near the close of the chapter. The northwest limit of this heavy coal seam is not fully determined. Deep borings at Girard show that it does not occur there. There is a general local feeling that it has quite narrow limits in a northwestern direction, but there are some indications that it extends much farther to the west and northwest than has usually been supposed. Above the heavy vein at a distance varying from 30 to 60 feet, a second or upper vein is located. It has an average thickness of from 25 to 30 inches, and is mined in many places throughout the coal-mining territory. The quality of the coal produced is almost as good as the lower vein. In numerous places in the northwest part of Cherokee county and reaching over into Crawford county a third vein of coal is found ranging from 14 to 20 inches in thickness which is mined

in many places by the "strip pit" process. It is very easily reached along the eastern border of the Lightning creek valley.

To the southwest, in the environs of Oswego and Chetopa, and farther southwest in the Indian Territory, coal is mined to considerable extent, but the veins cannot be correlated with the Weir City-Pittsburg coal, although they occupy about the same vertical position.

These different coal seams are not perfectly uniform in vertical position, but they do not vary any more than coal seams usually do. In fact the two heavier ones vary much less than is customary with similar coal seams throughout the Mississippi valley. The marsh or lagoon in which the coal plants were collected had an unusually level and even bottom, and it must have been at least 20 or 30 miles in length, for good workable coal is found continuously throughout that great a distance.

Farther north in the vicinity of Fort Scott coal is found within 8 or 10 feet of the summit of the Cherokee shales. The veins average about 13 inches in thickness, but in places it is a little more. It is so close to the "cement" rock that usually the latter has to be removed to obtain the coal. The numerous creeks and little ravines for miles around Fort Scott have cut down through the "cement" rock, leaving the coal exposed on the banks. It has been mined in hundreds of places by the "stripping" process, the coal having been followed back into the bank 10, 20, 30, or more feet dependent upon the thickness of the covering. The coal follows the Oswego limestone southward as they rise into the high anticlinal ridge towards Pittsburg, through all of which distance it has been mined. Along the high parts of the divide the "stripping pits" from which the coal has been taken are no unusual sight.

The Cherokee shales extend north to Leavenworth and beyond, where the Leavenworth coal is found at about the middle of their thickness. In sinking the shaft for operating the mines numerous coal seams were passed before the one was reached which furnishes the coal, and by drilling it was learned that at still greater depths other coal of equally good quality and thickness exists. In position, therefore, the Leavenworth coal is about the same as the Pittsburg-Weir City coal beds. The records of the various drill holes which have been sunk between Pittsburg and Leavenworth show that there is more or less coal scattered throughout the whole distance. It should not be understood, however, that the Leavenworth coal seam is a continuation of either one of the Pittsburg seams. This would be exceedingly improbable, and the various drillings referred to show conclusively that the two seams are in no sense of the term continuous. Yet throughout the whole of the Cherokee

shales period the conditions in general were favorable for the growth and accumulation of coal forming materials, so that in the aggregate vastquantities of the material were formed. According to the estimates given in the Report of our State Mine Inspector for 1893, the total output of coal from the Cherokee shales aggregated 85.79 per cent. of the total output for the state. It may be stated that this not only shows how the coal-mining operations are conducted at present, but also gives a fair indication of the way we may reasonably expect them to be developed in the future. The Cherokee shale beds are *par excellence* the great coal-producing formations of the state.

### THE PLEASANTON SHALES.

Above the Cherokee shales little coal exists anywhere in the state below the Pleasanton shales. In a few places small amounts have been seen in the shales between the Oswego and Pawnee limestones, but it has not been mined at any place so far as known to the Survey except in one point to the southwest of Fort Scott. But when the Pleasanton shales are reached large quantities of coal of an excellent quality are found at their very base, or within less than 20 feet of the Pawnee limestone, which places it only about 100 feet above the top of the Cherokee shales. The principal mines are located at Pleasanton, Boicourt, and La Cygne, at which places the coal is reached by shafting to a depth of from 50 to 90 feet, the exact distance varying considerably with the surface contour. The vein is from 30 to 34 inches in thickness, so that it can be extensively mined with profit.

In other places, particularly around Mound City, still within the Pleasanton shales, other seams of coal are found which are worked either by the stripping process or by drifting. To the south of Pleasanton all the way to Fort Scott coal is frequently mined locally. At some of the mines the coal seam is from 20 to 30 inches thick, but usually from 15 to 25 inches. The exact geologic horizon of many of these places has not been determined. Some of them should undoubtedly be corellated with the Fort Scott "red" coal, and others probably with the Plasanton coal, while Mr. Bennett is inclined to believe that at some of the mines the coal is in the shales between the Oswego and Pawnee limestones.

### THE THAYER SHALES.

Above the Pleasanton shales the next coal of any note lies within the Thayer shale beds, the base of which will average about 500 feet above the summit of the Cherokee shales, or 950 feet above the base of the Coal Measures. This coal is particularly noteworthy on ac-

count of its being the lowermost coal in the Upper Coal Measures as the divisions are made by this Survey. The coal is mined at many intervening points all the way from Independence to and beyond Thayer. Southeast of Independence the principal vein is located high up in the shale bed, as is also the coal at Brooks and Thayer. but in other cases to the southwest of Thayer towards Neodesha it would seem the coal is lower. It is quite certain, therefore, that two or more coal seams occur in those shales which probably are separated from 50 to 75 feet vertically.

The amount of coal in the Thayer shales is very considerable and the quality good. Almost all the communities for many miles around, including the various towns and villages along the railroad lines, are supplied with their fuel from this source.

### THE LAWRENCE SHALES.

In passing upward from the Thayer shales no more coal of any importance is found until the Lawrence shales are reached. They begin about 1400 feet above the base of the Coal Measures, and the coal within them is from 50 to 100 feet above their base. The coal is most abundant in Franklin county but reaches northward into Douglas county as well. It is most extensively mined to the west of Ottawa here and there over an area of many square miles. The coal seam is from 14 to 16 inches thick, and the coal is of fair quality, so that when used it compares quite well with the coal of the general markets. The mining is carried on by shafting and drifting. From the mines it is teamed to Ottawa or other neighboring towns, and is loaded on cars at Pomona and shipped to the general market.

The Douglas county mines are almost entirely abandoned at present. Years ago, before the coal of the general markets became so reasonable in cost, mining operations were carried on in a dozen or twenty different places over a large area to the south of Lawrence. The coal has the same horizon occupied by the Franklin county coal but is not quite so heavy, ranging from 10 to 15 inches in thickness, and consequently cannot be placed on the general markets in competition with other coals at the prices now prevailing.

Although other portions of the state have the surface covered with the Lawrence shales, yet so far as learned they do not contain coal in sufficient quantity to justify mining.

### TOPEKA COALS.

Just west of Topeka coal is mined to a limited extent, and to a greater extent around Silver Lake and Dover. The two coal fields, however, are quite different geologically although so closely related

geographically. The Topeka coal is fully 125 feet lower than the coal at Silver Lake. The latter belongs to the same horizon with the Osage City coal.

The Topeka coal is about 2075 feet above the base of the Coal Measures, and is not the geologic equivalent of any other coal known in the state, unless possibly the coal claimed to have been discovered recently in Jefferson county should be correlated with it. The importance of the Topeka coal is not very great, for the mining operations are limited.

### THE OSAGE CITY SHALES.

The coals occupying these shales are remarkable for constituting so extensive a deposit at so high a point within the Coal Measures. They are located 2200 feet above the base of the Lower Coal Measures, yet in quantity and quality the coal will compare tolerably well with many coals in the Mississippi valley obtained from much lower horizons. The total output from this horizon in 1893 reached the large quantity of 7,018,942 bushels, equaling 9.742 per cent. of the total output of the state for that year, from Osage county alone, while a considerable amount came from Shawnee county.

The mines are principally located along the line of the Atchison, Topeka & Santa Fe Railroad between Topeka and Emporia at Carbondale, Scranton, Burlingame, Osage City, and other places. The coal seam outcrops to the southeast and is therefore first mined by stripping. When the dip has taken it too far under the surface to admit of profitable mining in this way, the ordinary shafting process is employed. The coal averages about 16 inches in thickness, but in many places exceeds this considerably. The depth at which it is reached of course will depend upon the position with reference to the outcroping and the particular surface contour.

Beyond the limits just given coal belonging to the same horizon has been mined in Coffey county near Lebo and Lyon county along its eastern line. Thin seams of coal are found in Greenwood county near Madison and southward, and in Elk county near Grenola, also in Chautauqua county at Leeds, in some of which places considerable mining is done. North of Osage City the same coal is mined at Dover and Silver Lake, two points which lie so close to Topeka that they are usually classed wtth the Topeka coal. Beyond this to the northeast traces of coal have been found in Jefferson county and at a few other points. This Survey has not yet done any detailed work in that part of the state, and therefore cannot speak authoritatively but presumably such coals should be correlated with the Osage City-Burlingame coal.

Above the Osàge City horizon no coal in paying quantity has been found in the Coal Measure area of the state.

## RESUME OF STRATIGRAPHY.

We have now mentioned all the coal producing horizons in the Coal Measures of the state, which may be summarized as follows:—

COAL BEARING HORIZONS OF KANSAS.

1. Cherokee Shales:—Located at base of Coal Measures, 450 feet thick.

   Coals:—Columbus coal; Weir City-Pittsburg, lower and upper; strip pit coal in northern part of Cherokee county; various coals around Oswego; Leavenworth coal.

2. Pleasanton Shales:—Located above Pawnee limestone and below the Erie, or Triple limestone, 235 feet thick, with base 550 feet above base of Coal Measures.

   Coals:—Pleasanton; Boicourt; La Cygne; and Mound City coals.

3. Thayer Shales:—Located between the Iola and Erie limestones, from 100 to 250 feet thick, with base about 1000 feet above base of Coal Measures.

   Coals:—Thayer coal; Brooks coal; Neodesha coal; and Independence coal.

4. Lawrence Shales:—Located between the Garnett and Oread limestones, from 200 to 300 feet thick, with base about 1400 feet above base of Coal Measures.

   Coals:—Franklin county coal, and Douglas county coal.

5. Topeka Coals:—Isolated, 2075 feet above base of Coal Measures.

6. Osage City Shales:—Over 100 feet thick, located above Topeka coals, and about 2100 feet above base of Coal Measures.

   Coals:—Chautauqua and Elk county coal; Coffey and Lyon county coal; Osage City coal; Scranton coal; Burlingame coal; Carbondale coal; Dover and Silver Lake coal; and Jefferson county coal.

## PHYSICAL AND CHEMICAL PROPERTIES OF KANSAS COALS.

But little work has been done upon the Kansas coals in the way of exact physical tests and chemical examinations. Prof. Blake, of the department of physics in the University, years ago made a few tests of a number of varieties to determine their steam producing properties. The results were published in the Transactions of the Kansas Academy of Science, volume 11, page 46, 1888, the summary of which is here reproduced in full:

"SUMMARY.

"From these results, the Kansas coals thus far examined are to be arranged in the following order as regards their evaporative powers:

"[NOTE.—About one-half the evaporating powers here given will be obtained in practice.]

| Order. | NAME OF COAL | Table. | Lbs. water evaporated per lb. coal. | Duration of burning—seconds. | Calories gram—degrees centigrade. |
|---|---|---|---|---|---|
| 1 | Cherokee | A. | 13.42 | 65 | 7206 |
| 2 | Fort Scott | C. | 13.20 | 60 | 7088 |
| 3 | Linn County | E. | 12.76 | 65 | 6852 |
| 4 | Cherokee, upper vein / Leavenworth. | B. / D. | 12.54 | 50 / 75 | 6734 |
| 5 | Franklin County | G. | 12.32 | 125 | 6615 |
| 6 | Osage County | F. | 12.10 | 115 | 6498 |
| 7 | Cloud County | H. | 9.90 | 135 | 5316 |
| | For comparison: Best Indiana block (Clay County) | | 14.43 | .... | ...." |

In the State Mine Inspector's Report for 1893, page 179, a table is given comparing the relative values of coals from many different parts of America with a cord of standard oak wood. This might be called a comparison of the relative heating capacity of the different coals. This test was made by the United States Quarter Master General, and gave the following results:

TABLE SHOWING NUMBER OF POUNDS OF COAL EQUAL TO ONE CORD STANDARD OAK WOOD.

| | Pounds. | | Pounds. |
|---|---|---|---|
| Weir, Kas., lump | 1,988 | Linton, Ind. | 2,698 |
| Trinidad, Colo. | 2'066 | Lexington, Mo | 2,734 |
| Pittsburg, Kas | 2,069 | Spring Valley, Ill | 2,751 |
| Litchfield, Kas | 2,069 | Girard, Ill | 2,840 |
| Weir, Kas., mine run | 2,165 | Branch, Ill | 2,852 |
| Leavenworth, Kas | 2,307 | Hocking Valley, Ohio | 2,971 |
| Canon City, Colo | 2,323 | Lyford, Ind | 3,015 |
| White River, Wyo | 2,323 | Streator, Ill | 3,076 |
| Rich Hill, Mo | 2,369 | Boulder Valley, Colo | 3,176 |
| Pleasant Hill, Utah | 2,407 | Burlingame, Kas | 3,301 |
| New Kentucky, Ill | 2,477 | Scranton, Kas | 3,418 |
| Gallup, N. M | 2,489 | Mitchell, Colo | 3,645 |
| Mount Olive, Ill | 2,641 | Osage City, Kas | 3,710 |
| Ladd, Ill., third vein | 2,660 | All Pennsylvania anthracite, | 1,700 |
| Fort Scott, Kas | 2,670 | Cerrillos, N. M., anthracite. | 1,657 |

The chemical examinations were made by Prof. Bailey of the University, and were also published in the Transactions of the Kansas Academy of Science, volume 11, page 46. He determined the

amount of water, the volatile matter, the fixed carbon, and the amount of ash. The following table gives the results obtained:

"The *averages* as given above are collected in the following table:

| *NAME.* | *Water* | *Volatile.* | *Fixed carbon.* | *Ash.* |
|---|---|---|---|---|
| Cherokee | 1.94 | 36.77 | 52.45 | 8.84 |
| Cherokee, (upper vein) | 2.08 | 35.35 | 48.61 | 13.96 |
| Fort Scott | 2.94 | 41.76 | 47.55 | 7.75 |
| Leavenworth County | 2.69 | 39.21 | 47.41 | 10.69 |
| Linn County | 2.07 | 39.42 | 46.89 | 11.62 |
| Osage County | 6.76 | 41.59 | 40.86 | 10.79 |
| Franklin County | 7.55 | 44.40 | 37.68 | 10.37 |
| Cloud County | 13.70 | 46.14 | 28.52 | 11.64 |
| Pittsburg, Pa | 1.31 | 36.61 | 54.17 | 7.91 |
| Nebraska | 4.93 | 38.17 | 49.44 | 7.46 |
| Warren County, Mo | 6.75 | 36.40 | 45.75 | 11.10" |

It is desirable to have the two factors, water and ash, as low as possible, for neither of them can be of any value as a fuel. The relative amounts of volatile matter and fixed carbon should vary according to the use to which the coal is to be put. For making illuminating gas a high per cent. of volatile matter is desirable, but for evaporating and general heating purposes, and for coke making, the greater the amount of fixed carbon the better. Dr. Day has published tables comparing the per cent. by weight of coke obtained from 100 parts of bituminous coal from different parts of America. From his Report of 1893 on the Mineral Resources of the United States, page 418, it is learned that the average per cent. of coke produced from the Kansas coals was 62.8, while the highest of any was 66.7 per cent. from the Illinois coal.

From the foregoing tables of both the physical and chemical properties a few conclusions may be drawn. First, it may be considered established that the Kansas coals compare very favorably indeed with the bituminous coals of other states within the Mississippi valley, and fairly well with the soft coals of Ohio and Pennsylvania. Second, it will be seen that in every desirable respect the coals of the Cherokee shales are the best in the state, and that in general the higher the geologic position of any coal the poorer the grade of coal. Yet it may also be concluded that, in comparison with many other coals, our highest, the Osage City, is a good coal.

## COMMERCIAL VALUE OF KANSAS COALS.

The commercial value of coal is dependent upon many factors, the most important of all of which is the rate at which outside coal can be imported if the local production does not equal the demand, and the character of the market to be reached provided the local production exceeds the demand. Thus, in this state the local production

far exceeds the home demand in almost all places where coal is mined from the Cherokee shales, the Pleasanton shales, and the Osage City shales, while at almost all other points where it is mined the output falls short of supplying the local trade. The only way, therefore, to compare coal out puts is to consider the bushels or tons. The following table has been arranged from data taken from the Report of the State Mine Inspector for 1893, page 83.

TABLE SHOWING STATISTICS ON PRODUCTION OF COAL FOR 1893 ARRANGED GEOLOGICALLY.

| *Geologic Formation.* | *County.* | *No. of Employes.* | *Per cent of State Output.* | *No. of Bushels.* | *Estimated Value.* |
|---|---|---|---|---|---|
| Cherokee Shales......... | Bourbon ...... | 185 | .659 | 475,000 | $ 33,250.00 |
| | Cherokee...... | 2,307 | 28.030 | 20,194,898 | 1,000,744.90 |
| | Crawford .... | 3,665 | 47.790 | 34,431,827 | 1,721,581.35 |
| | Labette. ...... | 40 | .139 | 100,000 | 9,000 00 |
| | Leavenworth. | 999 | 9.035 | 6,509,463 | 423,115.09 |
| Pleasanton Shales. . . . | Linn........... | 264 | 2.571 | 1,852,119 | 92,605.95 |
| Thayer Shales ........... | Montgomery. | | | | |
| | Neosho........ | ...... No | statistics | given. | |
| | Wilson ....... | | | | |
| Lawrence Shales...... .. | Franklin...... | 105 | .765 | 551,290 | 44,103 20 |
| | Douglas....... | ...... No | statistics | given. | |
| Osage City Shales...... .. | Atchison?.... | 25 | .003 | 2,375 | 213.75 |
| | Chautauqua .. | 33 | .062 | 44,000 | 4,400.00 |
| | Coffey. ........ | 95 | .520 | 375,000 | 32,812.50 |
| | Osage.......... | 1,973 | 9.742 | 7,018,946 | 529,899.61 |
| | Shawnee*..... | 54 | .265 | 190,835 | 22,900.20 |
| | | 9,735 | 99.581 | 71,745,553 | $3,923,626.55 |
| Brown coal from western counties.. .... | | ........... | .... ....... | ......... | 36,725.09 |
| Grand Total......... ........... ..... | | ....... ... | ... .... .. | ...... .... | $3,960,351.64 |

* Including coal from the Topeka mines not separated in available statistics.

It is interesting to compare the output of Kansas coal for different years, and the same with that of other neighboring states during a period of years. For this purpose the following table is added, the material of which is gathered from Mineral Resources of the United States for 1893:

| *STATE.* | *1891.* | | *1892.* | | *1893.* | |
|---|---|---|---|---|---|---|
| | *Product* | *Value.* | *Product.* | *Value.* | *Product.* | *Value.* |
| | *Short tons.* | | *Short tons.* | | *Short tons.* | |
| Alabama............ | 4,759,781 | $5,087,596 | 5,529,312 | $5,788,898 | 5,136,935 | $5,096,792 |
| Arkansas ........... | 542,379 | 647,560 | 535,558 | 666,230 | 574,763 | 773,317 |
| Colorado*..... .... | 3,512,632 | 4,800,000 | 3,510,830 | 5,685,112 | 4,102,389 | 5,104,602 |
| Illinois.... ....... .. | 15,660,698 | 14,237,074 | 17,862,276 | 16,243,645 | 19,949,564 | 17,827,595 |
| Iowa................ | 3,825,495 | 4,867,999 | 3,918,491 | 5,175,060 | 3,972,229 | 5,110,460 |
| Kansas.... ...... .. | 2,716,705 | 3,557,303 | 4,007,276 | 3,955,595 | 2,652,546 | 3,375,740 |
| Missouri ...... ..... | 2,674,606 | 3,283,242 | 2,733,949 | 3,369,659 | 2,897,442 | 3,562,757 |
| Pennsylvania* ..... | 42,788,490 | 37,271,053 | 46,694,576 | 39,017,164 | 44,070,724 | 35,260,674 |

* Bituminous coal only.

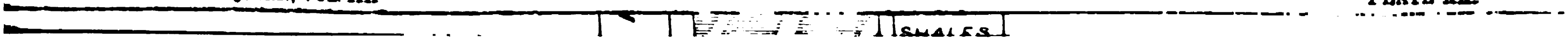
There is a slight discrepancy between the figures for Kansas for 1893 as given in the Report of the State Mine Inspector and those

given by the governmental publications. As our State Mine Inspector was on the grounds and had the best of opportunities, the probabilities would favor the correctness of his Report.

### PROBABLE FUTURE OF COAL MINING IN KANSAS.

There are good reasons for believing that coal mining in Kansas will increase with comparative rapidity during the coming years. There can be no reasonable doubt that the quantity within the Coal Measure area is much greater than has been usually estimated by those interested in such matters. The records of the various deep wells drilled by those prospecting for oil and gas show that in many places coal of considerable quantity was passed through, which might often be mined were there a sufficient demand for it. Further, as has been shown in these pages, our state is full of thinner seams of good coal which cannot now be mined on account of the low price of coal. But should the price advance only from one to two cents per bushel many of them now untouched could be successfully operated. There is, therefore, little ground for apprehension regarding the exhaustion of our coal mines within a few centuries, or for the material advance in price.

Many inquiries have been made of the Survey regarding the probabilities of deep borings reaching coal in the west central portions of the state. We are not now in possession of sufficient data upon which to base predictions that will be of any special value. In general it may be said that the Lower Coal Measure strata maintain their thickness westward much better than had previously been supposed by geologists in general. The Cherokee shales maintain almost their full thickness to as far west as Neodesha and Fredonia with considerable quantities of coal, as is shown by the 27-inch vein at Cherryvale, and this indicates that possibly they and other formations may continue westward for 100 or 200 miles more. We are in possession of no authentic records of deep wells further west than Fredonia. Could a few wells be drilled about Wichita, Hutchinson, and to the north, which would pass almost to the base of the Coal Measures they would throw much light upon the general stratigraphy of the deeply buried formations and, whether they passed through coal or not, would be a great help in the intelligent prediction of the probable conditions of the presence or absence of coal in any considerable quantities. It is earnestly hoped that in the future accurate records of all deep wells within the state will be permanently preserved. At present little encouragement can be given to the hope that coal in paying quanties could be reached in those localities by shafting.



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## VOL. II.

### No. 1.



### No. 2.



### No. 3.



### No. 4.